MOORE

Tests on the Thermal Conductivity Of Terra Cotta Fireproofing

Ceramics

B. S.

1908

TESTS ON THE THERMAL CONDUCTIVITY

OF

TERRA COTTA FIREPROOFING

BY

JOSEPH KENNEDY MOORE

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CERAMICS

IN THE

COLLEGE OF SCIENCE

OF THE

UNIVERSITY OF ILLINOIS

PRESENTED JUNE 1908

UNIVERSITY OF ILLINOIS

May 29 1908

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Mr. Joseph Kennedy Moore

ENTITLED Tests on the Thermal Conductivity of Terra Cotta Fireproofing.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Ceramics

A. V. Bleininger
Instructor in Charge.

APPROVED: E. Orton Jr.

HEAD OF DEPARTMENT OF Ceramics

The Thermal-Conductivity

of

Terra Cotta Fire-proofing.

Outline

1. Introduction

2. Calibration of Instruments

3. Method

   (a) Description of Method
   (b) Making Test Pieces
   (c) Manipulation

4. Determination of Specific Heat

5. Description of Calculation

6. Conclusions

Introduction.

The increasing demand for fire resisting materials and the scarcity of data upon the subject, lead to this investigation. The fire-proofing on the market today is of all varieties, from that manufactured from the good grades of number two fire clay to that made from the softest burning glacial and alluvial clays. The question arises what properties must the product possess to make it a safe material for office-building construction.

Since the heat conductivity of fire-proofing is one of the most important constants to be determined, this determination was undertaken as described in the following pages. Many methods have been employed to determine the thermal conductivity of substances at low temperatures, but practically no work has been attempted at temperatures above 300 Centigrade. After going over the field (See references) it was decided to adopt the Neumann method as used by H. Hecht of the University of Koenigsberg. Many changes had to be made, however, to suit the working conditions. The method as decided upon is as follows:

To determine the Thermal conductivity of a fifteen centimeter burnt clay ball, by heating it to 1100 C and allowing it to cool within an ice-cooled air chamber, the temperature to be measured by means of two Le Chatelier thermo-couples, one to be placed in the center of the ball and the other on the surface.

In carrying out this work the following steps and auxiliary determination were carried out.

1. Calibration of the couples and galvanometers.
2. Preparing the clay and molding the pieces as well as burning them.

3. Determination of the mean specific heat of the clay.

4. Determination of the specific gravity of the clay.

In the investigation the object was first to determine the practical heat loss expressed in gram calories per cm. of the surface of the balls.

It was intended that these constants should serve as the criterion in differentiating between the heat conductivities of the several grog mixtures. The determination of these values, therefore, may be said to be the chief object of the work.

Calibration of Instruments.

Owing to the fact that thermo couples undergo changes during continued heating, it was found necessary to calibrate both the couples and also the galvanometer. This was done by determining the freezing point of copper, zinc, and silver and noting the correction at these temperatures. Since the equation governing these corrections is one of three parameters, the three points determined are sufficient to plot a correction curve for all temperatures within the range of the experiment.

Materials and Test Pieces.

The clay selected for this purpose was one which is being used in a successful commercial product and was of the No.3 fire clay variety, being of a slate color and possessing sufficient refractoriness and plasticity for the purpose. The grog usedwas made from broken pieces of burned fire-proofing which was made from the above clay.

The clay was made to pass an 8 mesh sieve after coming from the dry pan. The grog was prepared by running the broken fire-proofing

through a jaw crusher and sieving into two grades, that which passed a ten mesh sieve and remained on a 20 mesh and that which passed the twenty mesh and remained on a forty mesh sieve.

After preparing the clay and grog they were weighed out and batches containing 0-5-10-15-20% grog were made up as per table below.

No. of Ball	% Grog	% Water Added	Size of Grog
0	0	15 %	0
1	5	"	10-20 Mesh
2	10	"	10-20 Mesh
3	15	"	10-20 Mesh
4	20	"	10-20 Mesh
5	5	"	20-40 Mesh
6	10	"	20-40 Mesh
7	15	"	20-40 Mesh
8	20	"	20-40 Mesh

The clay mixture was then wedged to a good working consistency and pressed into shape in the plaster mould (Fig.3). After drying the clay a hole 3/8" was drilled by means of a drill press to the center of the ball (See Fig.1 A) in order to introduce the thermo couple, also the small 1/8" hole was drilled 1/10 inch into the surface for the outer couple to be cemented to (See Fig.1 B). The balls were then burned to Seger Cone .02 in a down draft test kiln.

(c) Manipulation.

After the balls had been burned they were again placed in the kiln and heated up to 1100 C. and the kiln held at this temperature.

A calorimeter (See A. Fig.2) was packed with ice and the ball drawn from the kiln. The inner and outer couples were then placed in position as illustrated, the inner couple being packed with asbestos

fibre and insulated by an insulating mixture consisting of 50% Mg O 50 Mg Cl to which 4% sodium silicate was added. The ball was introduced into the calorimeter and on a small tripod made from the same material as the ball itself. The cover was then placed in position and covered with ice and the readings taken on galvanometer D, using a double throw switch C. The copper junction of the thermo couple was soldered to the platinum wire and kept in an ice bath B. The fall of temperature as shown by the galvanometer readings was recorded for each minute, the correction for the error due to the couple computed, and the difference between the outside and inside couple determined.

(a) Determination of Specific Heat.

It was now necessary to determine the specific heat at three temperatures in order to compute the mean specific heat over the total range of temperature. The method employed was that of mixtures. (Heat for Advanced Students) Edser, pp.122-130.

However, it was found necessary to enclose the sample in an asbestos cartridge in order not to lose heat in taking the sample from the furnace and introducing it into the calorimeter. The furnace employed was an electric resistance furnace and the temperature of the furnace measured by a thermo couple.

A. The data is shown in the following paragraphs.

Fig 1

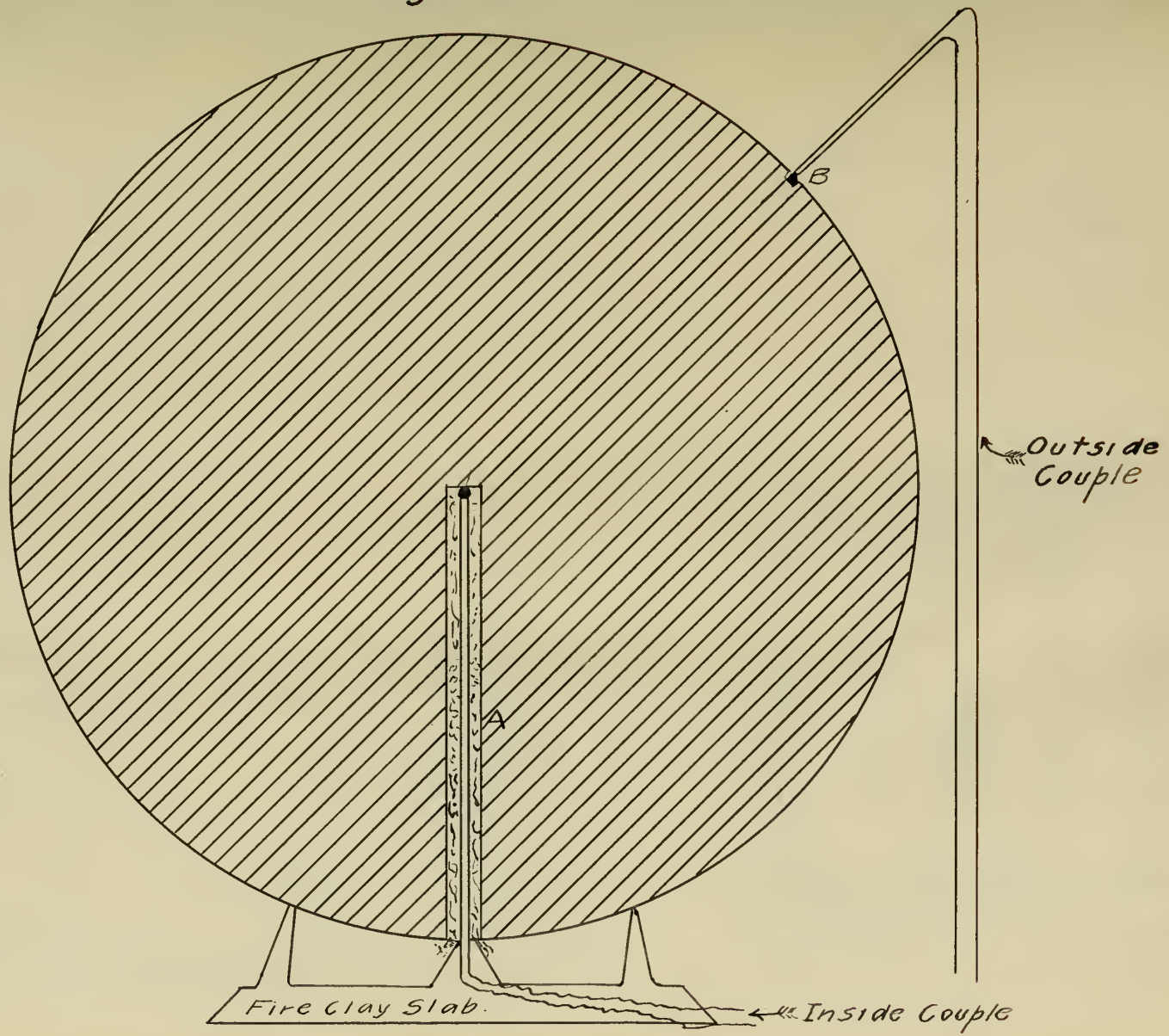

B
A
Outside Couple
Asbestos Packing
Fire Clay Slab.
Inside Couple

Fig 2

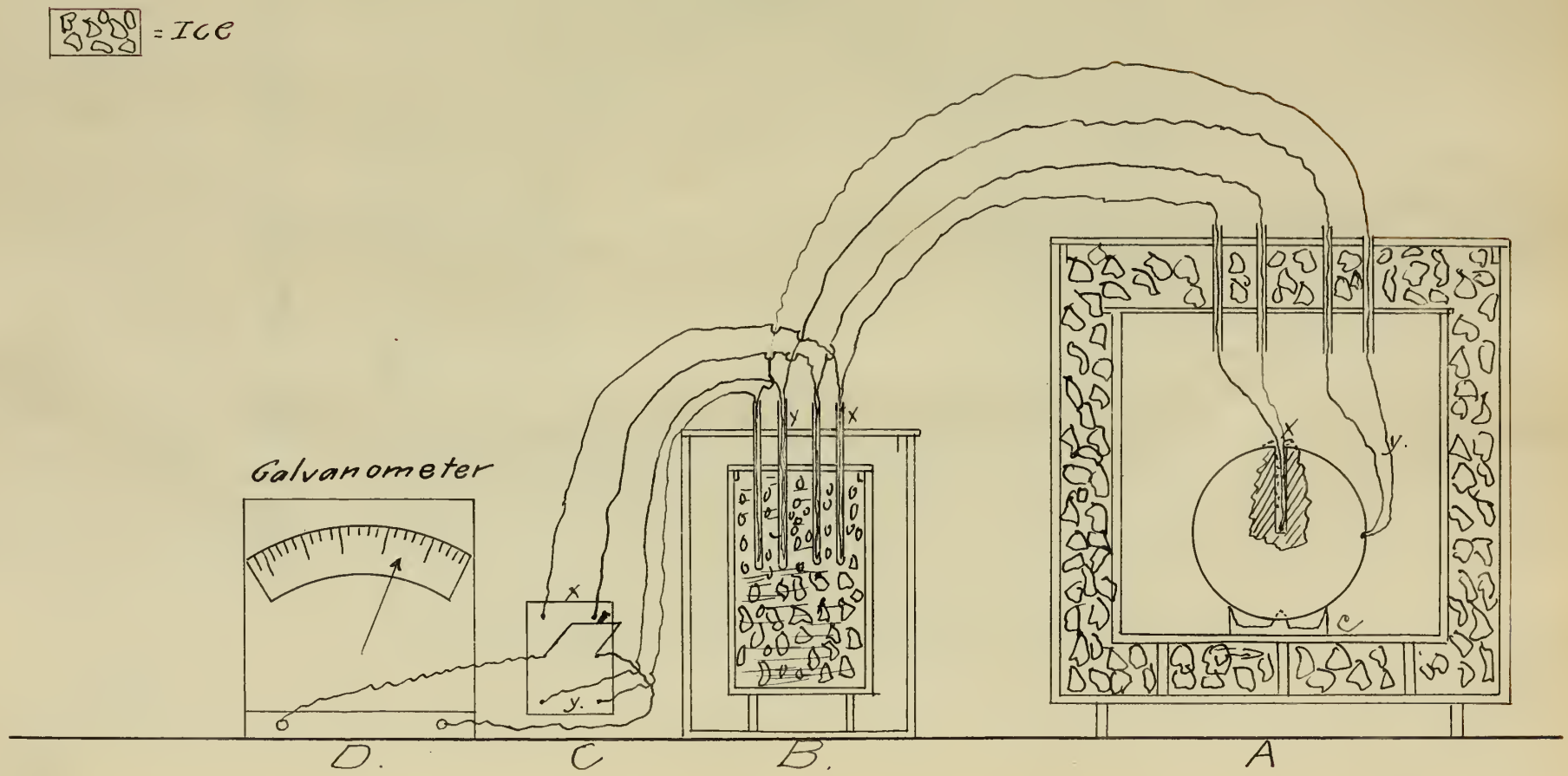
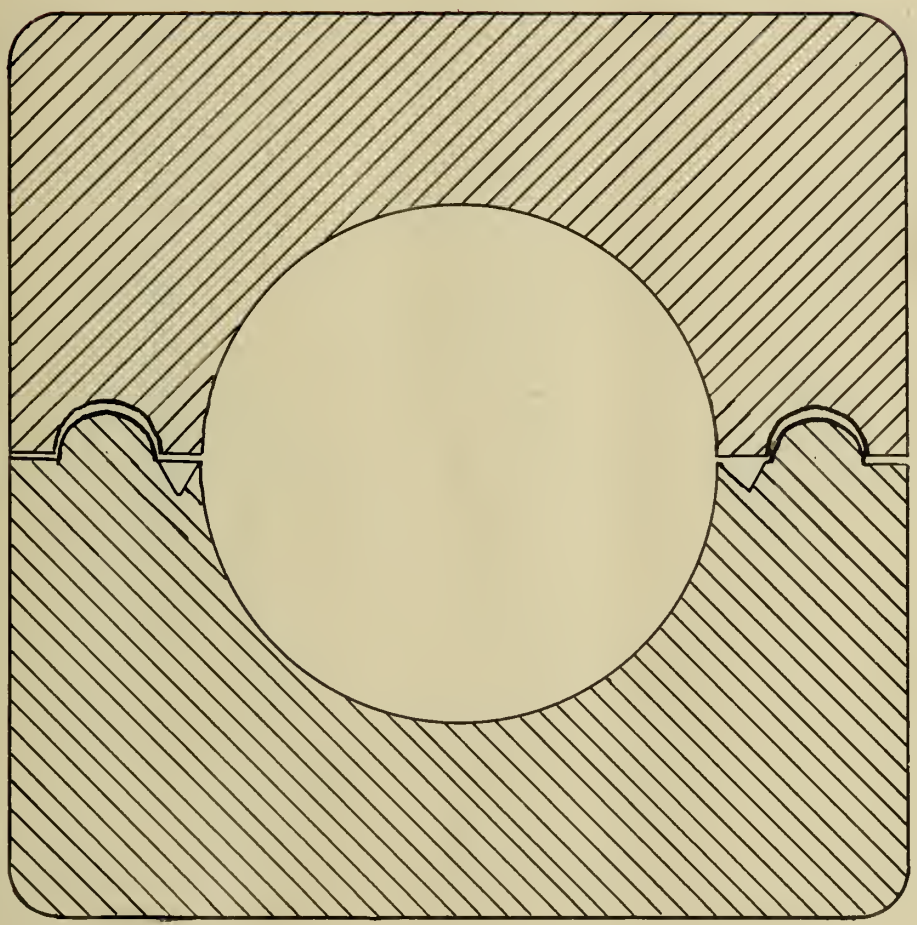
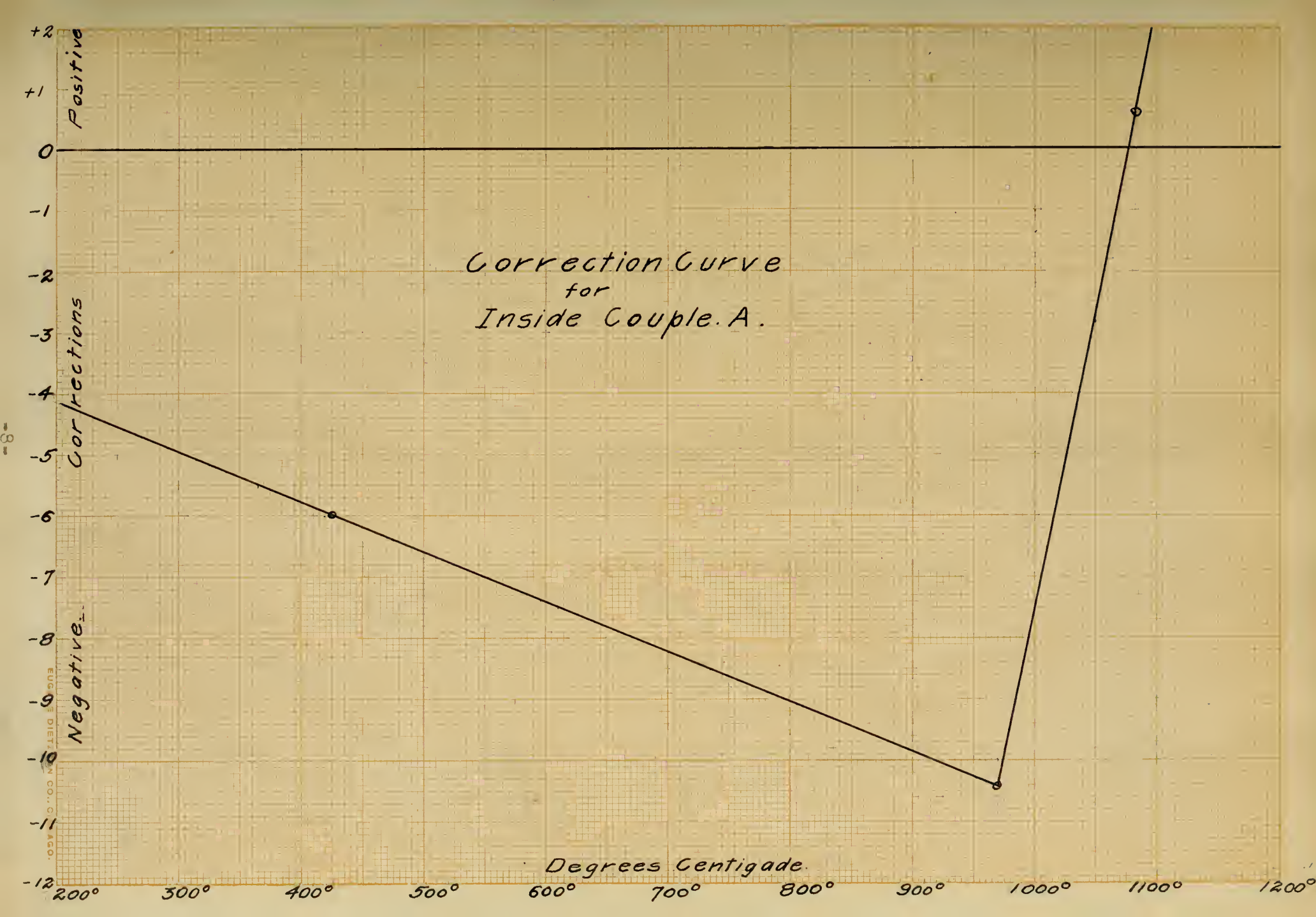
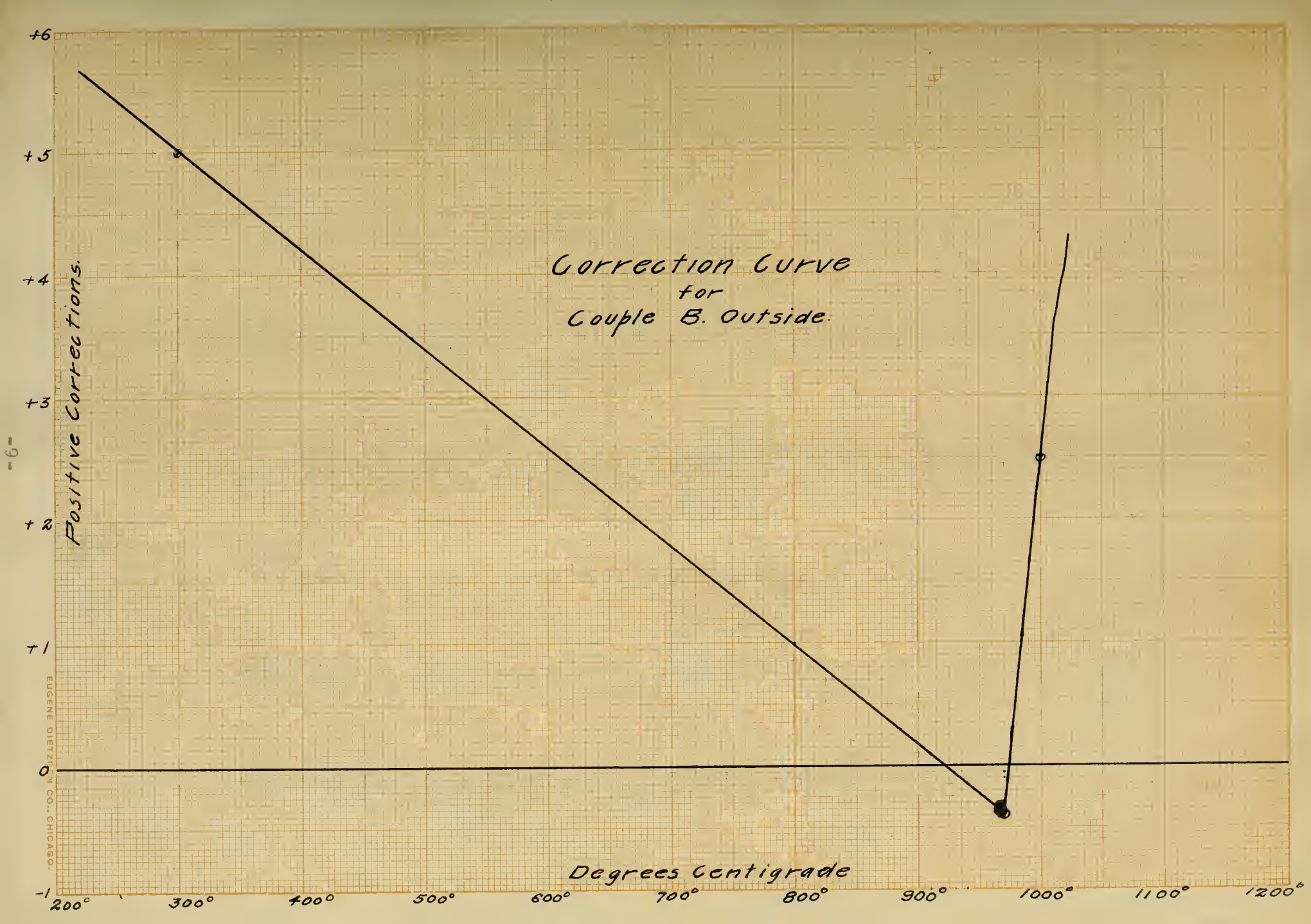


Fig 3.



Plaster Press Mould.


Correction Curve
for
Inside Couple. A.
Positive
Negative
Corrections
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
200°
300°
400°
500°
600°
700°
800°
900°
1000°
1100°
1200°
Degrees Centigade.

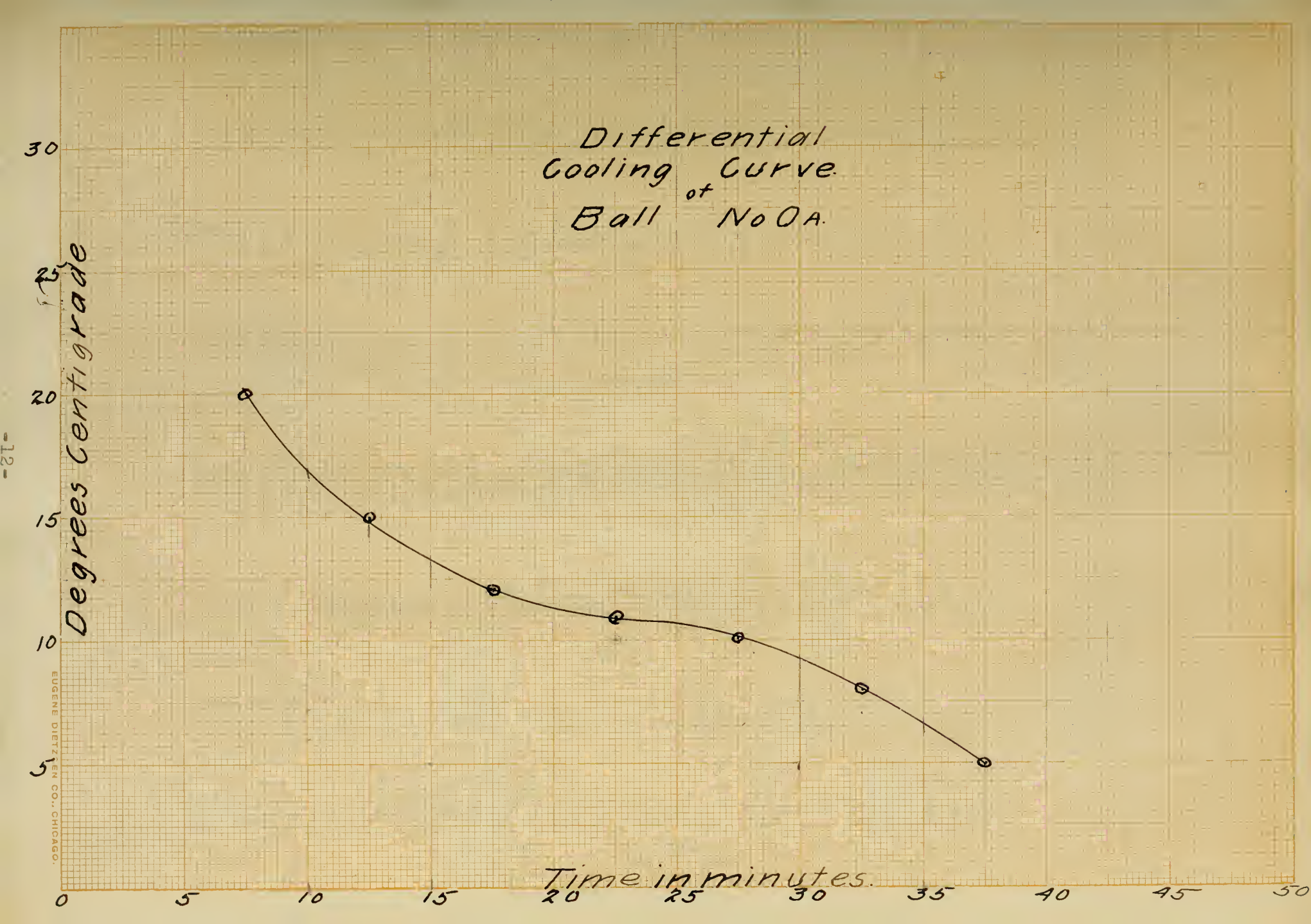


D A T A S H E E T.

Ball No. Oa.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
1	1160			570			
2	1140			555			
3	1120			540			
4	1100			530			
5	1070	-1	1069	515	3	518	571
6	1050	-2.8	1047	505	3	508	539
7	1025	-5	1020	495	3	498	522
8	1000	-8	992	490	3	493	499
9	975	-10	965	475	4	479	486
10	950	-10	940	465	4	469	471
11	925	-10	915	455	4	459	456
12	900	-10	890	450	4	454	436
13	876	-10	866	440	4	444	422
14	850	-9	841	430	4	434	407
15	830	-9	821	425	4	429	392
16	810	-9	801	420	4	424	377
17	790	-9	781	410	4	414	367
18	770	-9	761	400	4	404	357
19	750	-9	741	390	4	434	347
20	725	-8	717	380	4	484	333
21	705	-8	697	370	4	474	323
22	690	-8	682	370	4	474	308
23	670	-8	662	360	5	365	297
24	655	-8	647	350	5	355	292
25	640	-8	632	345	5	350	282
26	625	-8	617	340	5	345	272
27	610	-8	602	335	5	340	262
28	595	-7	588	332	5	337	251
29	580	-7	573	330	5	335	238
30	570	-7	563	325	5	330	230
31	555	-7	548	320	5	325	223
32	545	-7	538	315	5	320	218
33	530	-7	523	310	5	315	208
34	520	-7	513	305	5	310	203
35	510	-7	503	300	5	305	198
36	500	-7	493	300	5	305	188
37	490	-6	484	295	5	300	184
38	480	-6	474	290	5	295	179
39	470	-6	464	285	5	290	174
40	460	-6	454	280	5	285	169
41	450	-6	444	275	5	280	164

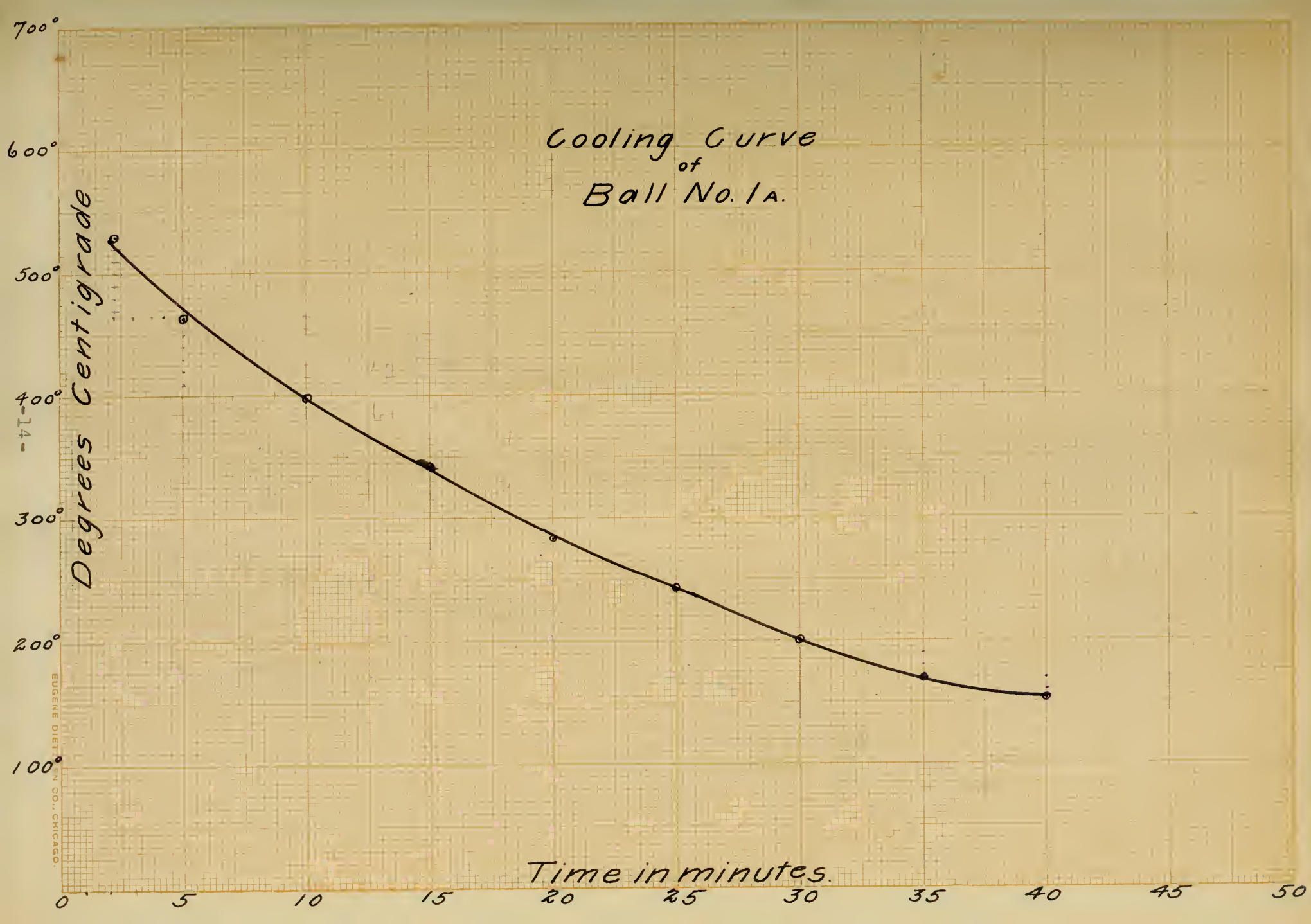

Cooling Curve.
of.
Ball No. OA.
Degrees Centigrade.
700°
600°
500°
400°
300°
200°
100°
0
0
5
10
15
20
25
30
35
40
45
50
Time in minutes

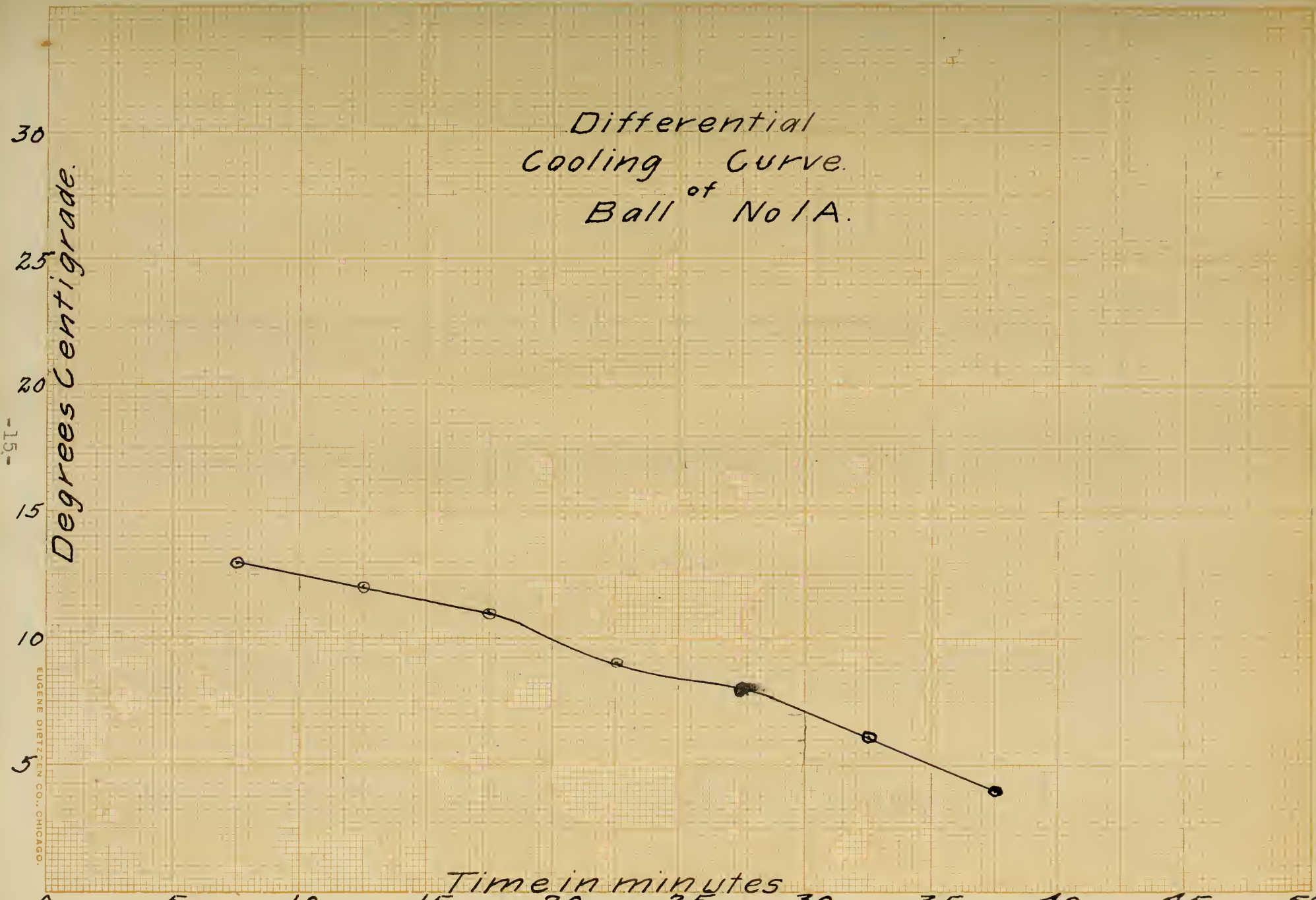

Differential
Cooling Curve
of
Ball No 0A.
Degrees Centigrade
30
25
20
15
10
5
Time in minutes.
0
5
10
15
20
25
30
35
40
45
50
EUGENE DIETZGEN CO., CHICAGO.

DATA SHEET.

Ball No. Ia.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1105			575			
1	1090			575			
2	1072	-1	1071	565	3	568	503
3	1055	-2	1053	555	3	558	495
4	1032	-5	1027	545	3	548	479
5	1010	-7	1003	538	3	541	462
6	980	-9	971	523	3	526	445
7	960	-10	950	520	3	523	437
8	940	-10	930	501	3	504	426
9	915	-10	905	495	3	498	407
10	895	-10	885	485	3	488	397
11	870	-10	860	475	4	479	381
12	847	-9	838	465	4	469	369
13	828	-9	819	455	4	459	360
14	805	-9	796	445	4	449	347
15	785	-9	776	430	4	434	342
16	765	-9	756	420	4	424	332
17	745	-9	736	412	4	416	320
18	725	-8	717	410	4	414	303
19	710	-8	702	400	4	404	298
20	690	-8	682	395	4	399	283
21	675	-8	667	390	4	394	273
22	660	-8	652	385	4	389	263
23	645	-8	637	376	4	380	250
24	630	-8	622	370	4	374	248
25	618	-8	610	365	4	369	241
26	600	-7	593	359	5	364	229
27	585	-7	578	351	5	356	222
28	575	-7	568	348	5	353	215
29	565	-7	558	340	5	345	213
30	550	-7	543	338	5	343	200
31	540	-7	533	330	5	335	198
32	530	-7	523	325	5	330	193
33	520	-7	513	320	5	325	188
34	508	-7	501	315	5	320	181
35	490	-6	484	309	5	314	170
36	488	-6	482	305	5	309	173
37	480	-6	474	300	5	305	169
38	470	-6	464	295	5	300	164
39	460	-6	454	289	5	394	160
40	450	-6	444	285	5	390	154

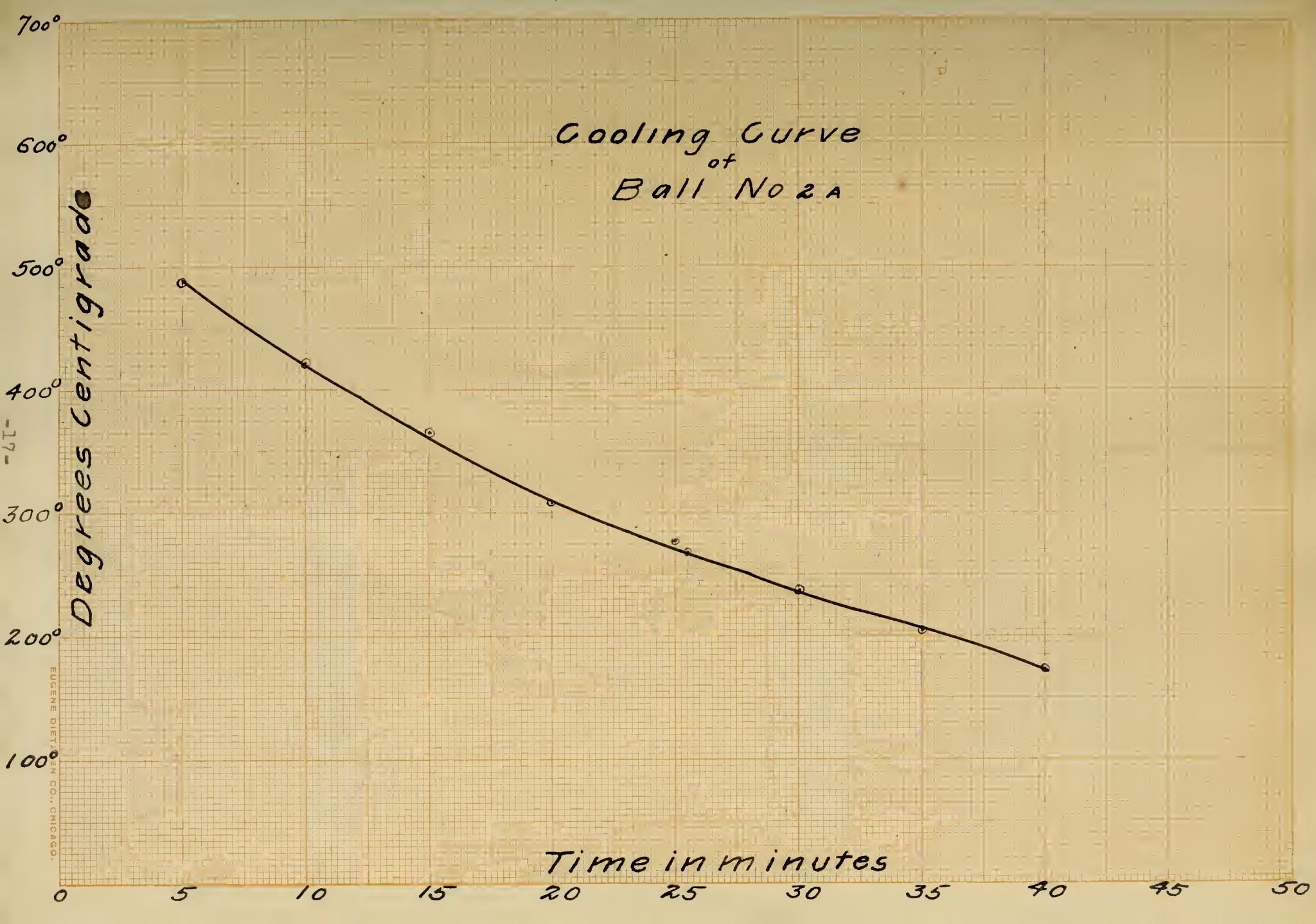


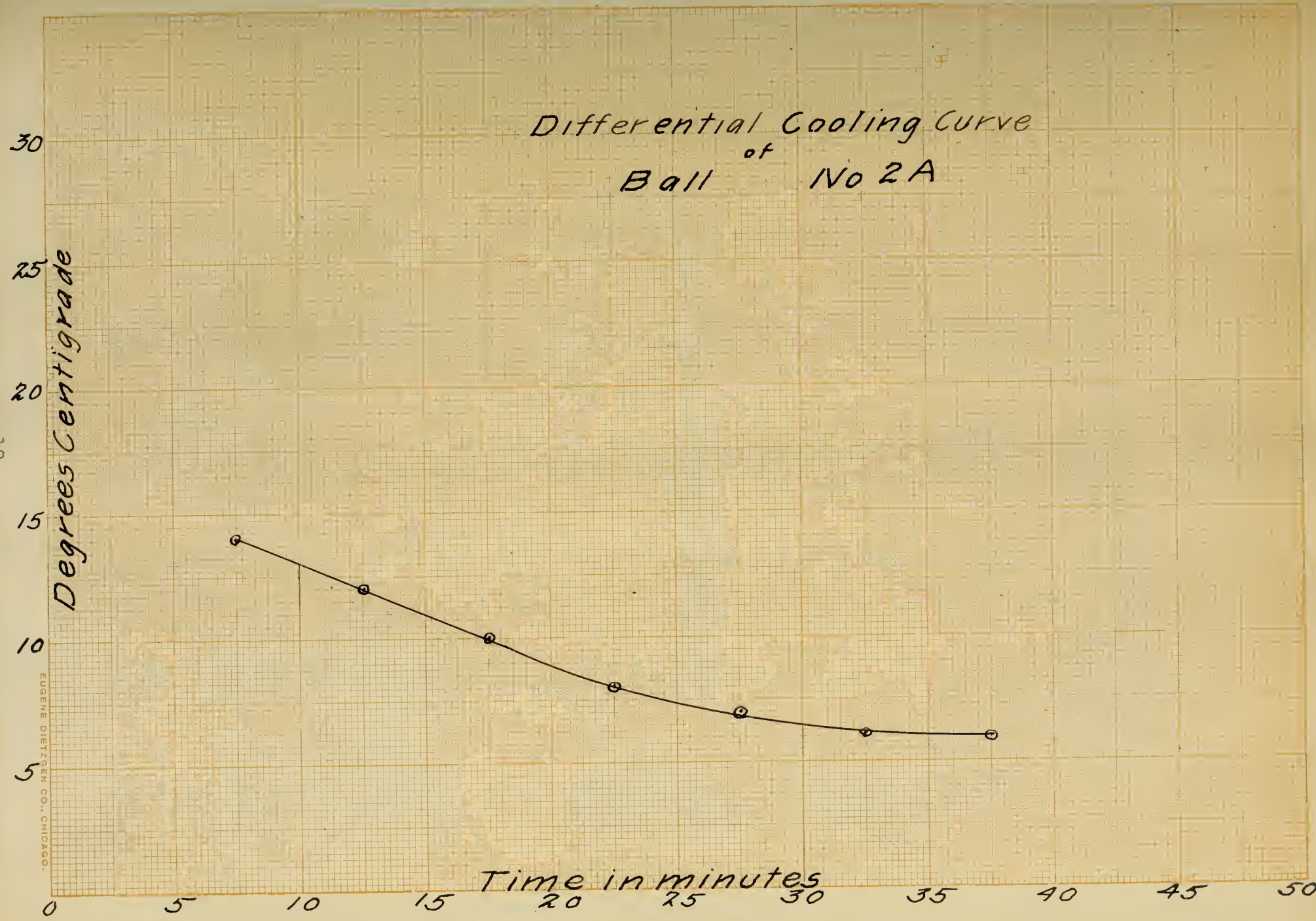


DATA SHEET.

Ball No. 2a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
1	1055	-2	1053	500	3	503	550
2	1045	-3	1042	515	3	518	524
3	1030	-4	1026	510	3	513	513
4	1005	-8	997	500	3	503	494
5	990	-9	981	490	3	493	487
6	975	-10	965	480	4	484	481
7	945	-10	935	470	4	474	461
8	930	-10	920	461	4	465	455
9	910	-10	900	452	4	456	444
10	880	-10	870	445	4	449	421
11	865	-10	855	440	4	444	411
12	840	-9	839	430	4	434	405
13	825	-9	814	420	4	424	390
14	805	-9	794	415	4	419	375
15	785	-9	774	405	4	409	365
16	770	-9	761	400	4	404	357
17	746	-9	737	390	4	394	343
18	730	-8	722	385	4	389	333
19	712	-8	704	380	4	384	320
20	695	-8	683	370	4	374	309
21	680	-8	672	365	5	370	302
22	662	-8	654	355	5	360	294
23	650	-8	642	350	5	355	287
24	632	-8	624	340	5	345	279
25	622	-8	614	333	5	338	276
26	609	-7	602	329	5	334	268
27	597	-7	590	325	5	330	260
28	580	-7	573	320	5	225	248
29	562	-7	555	310	5	315	240
30	555	-7	548	307	5	312	236
31	542	-7	535	301	5	3 06	229
32	532	-7	525	299	5	304	221
33	520	-7	513	290	5	295	218
34	511	-7	504	290	5	295	209
35	500	-7	493	285	5	290	203
36	490	-6	484	281	5	286	198
37	480	-6	474	280	5	285	189
38	470	-6	464	275	5	280	184
39	461	-6	455	270	5	275	180
40	452	-6	446	270	5	275	171
41	443	-6	337	265	5	270	167
42	435	-6	329	260	5	265	164
43	427	-6	421	255	5	260	161
44	420	-6	414	250	5	255	159

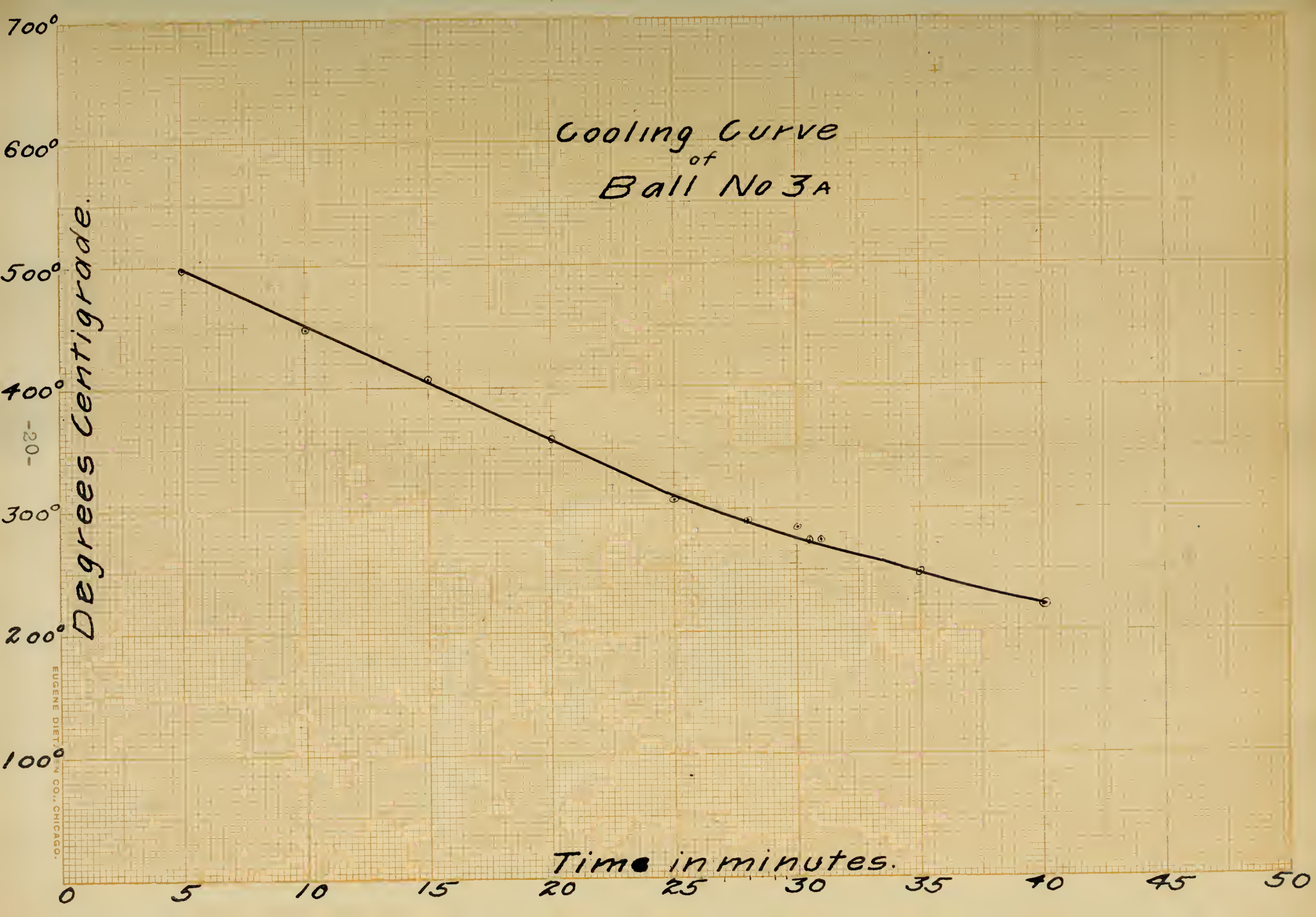


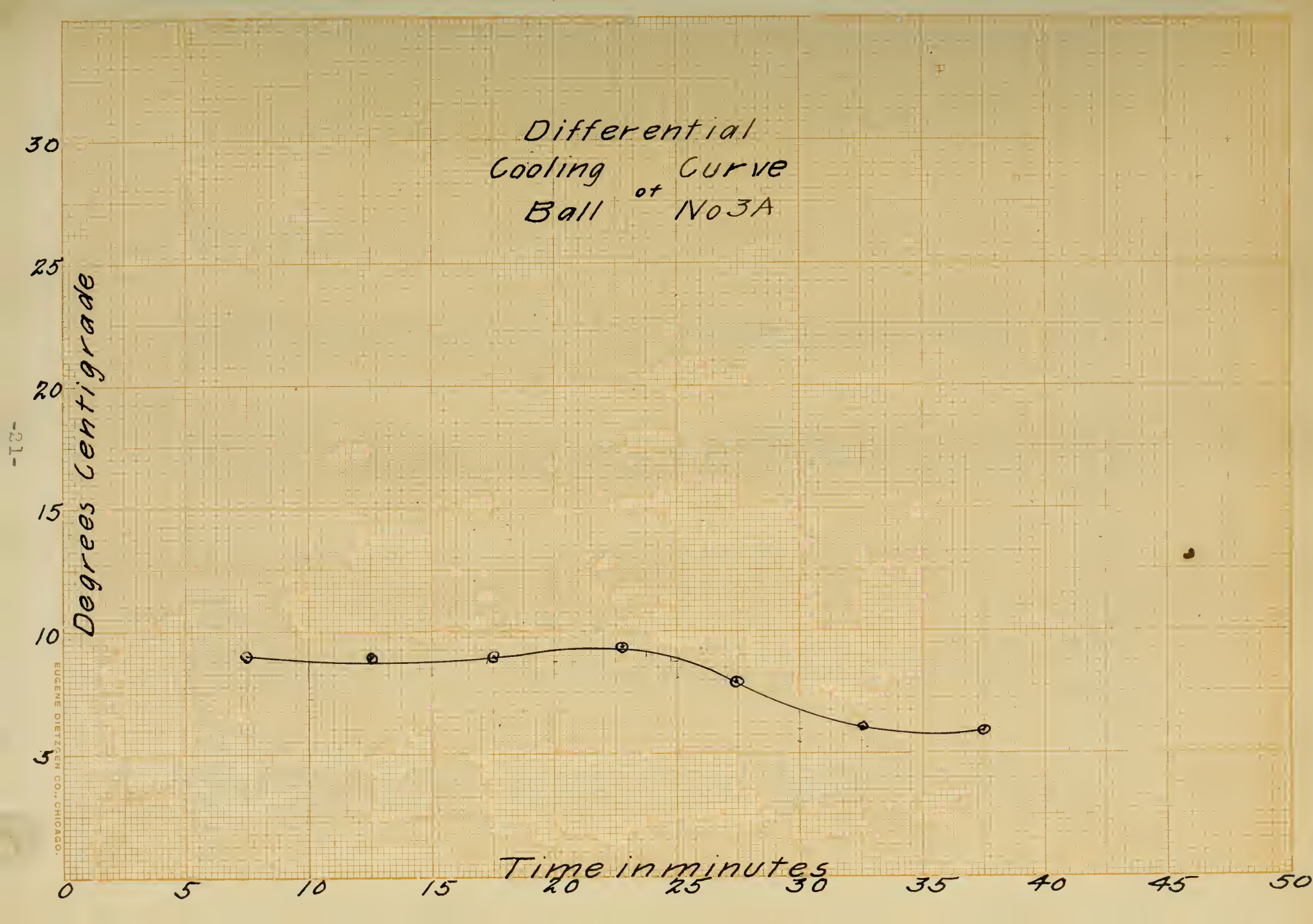


DATA SHEET.

Ball No. 3a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
1	1035	-4	1031	500	3	503	524
2	1020	-6	1016	490	3	493	523
3	1003	-8	995	480	4	484	511
4	987	-9	976	470	4	474	504
5	975	-10	965	465	4	469	496
6	958	-10	548	453	4	458	490
7	935	-10	925	440	4	444	481
8	920	-10	910	430	4	434	476
9	903	-10	893	419	4	423	470
10	880	-10	870	418	4	422	458
11	869	-10	859	410	4	414	445
12	850	-9	841	400	4	404	437
13	830	-9	821	395	4	399	422
14	815	-9	804	389	4	393	411
15	800	-9	791	381	4	385	406
16	782	-9	773	378	4	382	291
17	769	-9	760	370	5	375	385
18	755	-9	744	360	5	365	379
19	748	-9	739	359	5	364	375
20	722	-8	714	356	5	355	359
21	707	-8	699	345	5	350	349
22	690	-8	682	340	5	345	337
23	678	-8	670	335	5	340	330
24	662	-8	654	330	5	335	319
25	647	-8	639	325	5	330	309
26	630	-8	622	321	5	326	296
27	620	-7	613	318	5	323	290
28	615	-7	608	313	5	318	290
29	607	-7	600	308	5	313	287
30	597	-7	590	300	5	305	285
31	586	-7	579	300	5	305	274
32	575	-7	568	293	5	298	270
33	565	-7	558	290	5	295	263
34	555	-7	548	290	5	295	253
35	545	-7	538	285	5	290	248
36	535	-7	528	280	5	285	243
37	528	-7	521	280	5	285	236
38	519	-7	512	275	5	280	232
39	510	-7	503	270	5	275	228
40	501	-7	494	269	5	274	220
41	490	-6	484	265	5	270	214
42	485	-6	479	260	5	265	214
43	477	-6	471	260	5	265	206
44	468	-6	462	253	5	258	204
45	459	-6	453	250	5	255	198

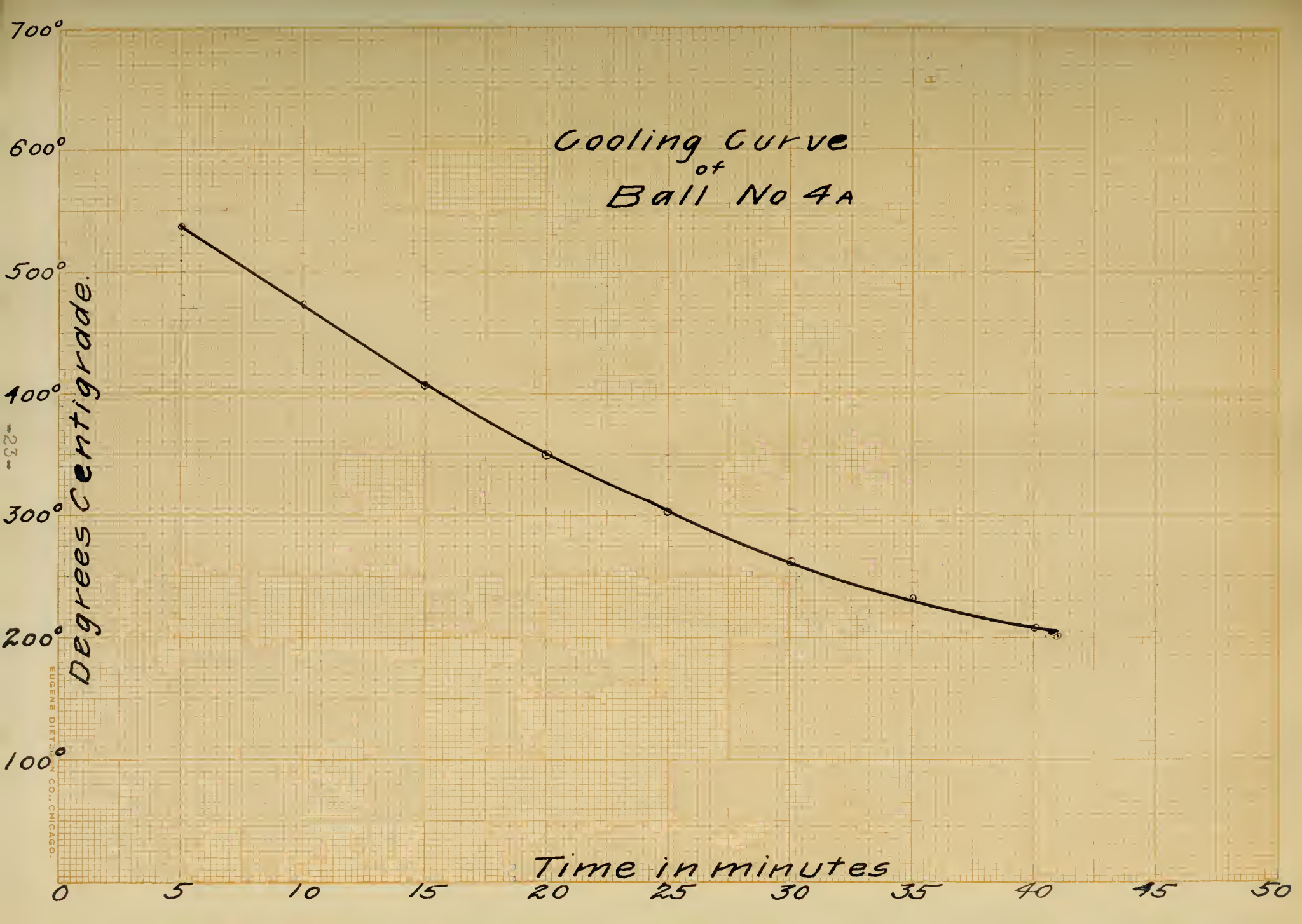


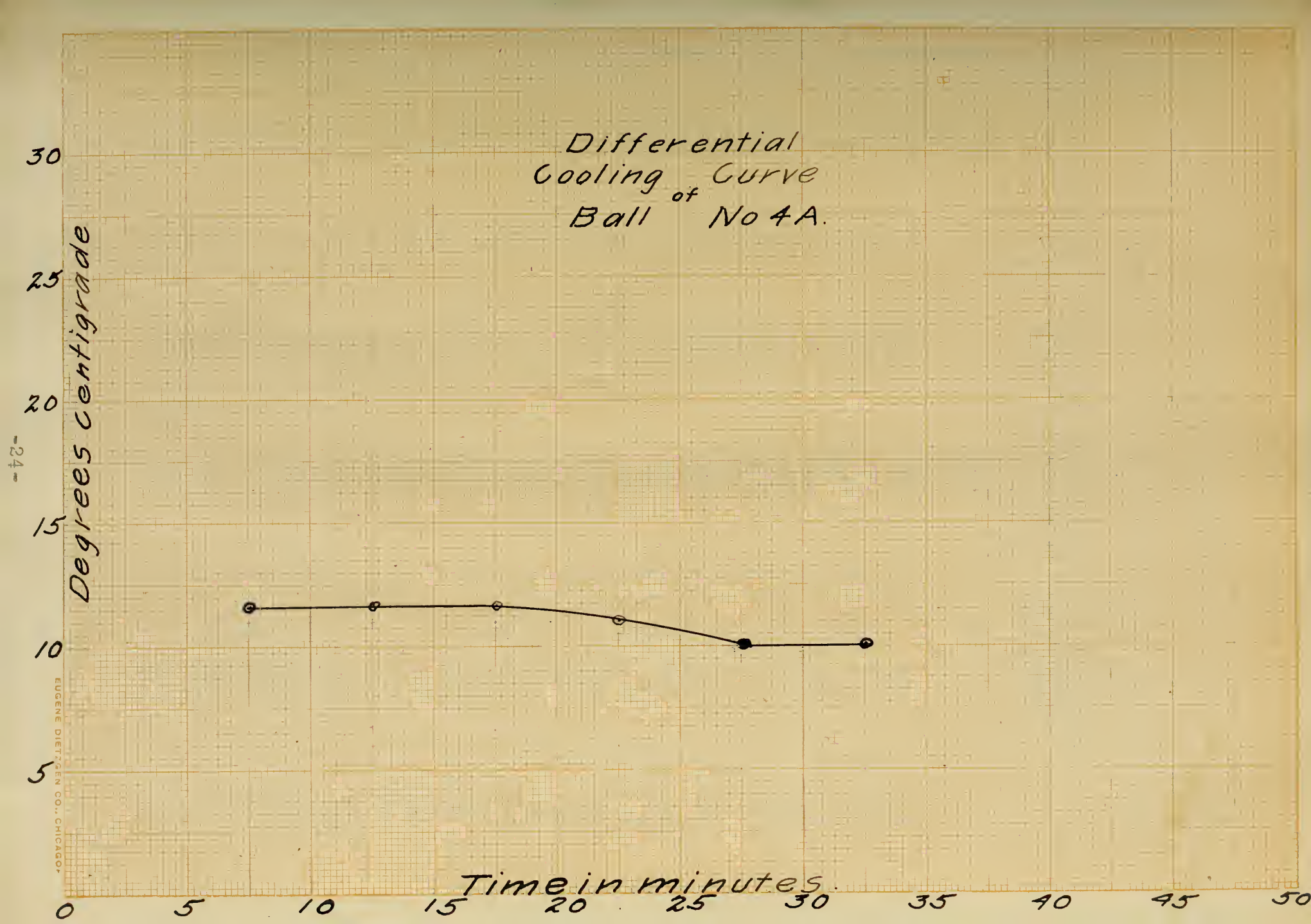


D A T A S H E E T.

Ball No. 4 a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1140			440			
1	1080	-0	1080	460	4	464	616
2	1045	-3	1042	460	4	464	578
3	1030	-4	1026	450	4	454	572
4	1010	-7	1003	445	4	449	554
5	980	-9	971	430	4	434	537
6	960	-9	951	425	4	429	522
7	940	-10	930	415	4	419	511
8	915	-10	905	410	4	414	491
9	890	-10	880	400	4	404	476
10	875	-10	865	390	4	394	471
11	855	-10	845	380	4	384	461
12	833	-9	824	373	4	377	447
13	811	-9	802	363	5	368	434
14	790	-9	781	360	5	365	416
15	775	-9	766	355	5	360	406
16	756	-9	745	350	5	355	390
17	738	-9	729	340	5	345	384
18	720	-8	712	330	5	335	377
19	700	-8	692	326	5	331	361
20	685	-8	677	322	5	327	350
21	670	-8	662	320	5	325	337
22	655	-8	647	311	5	316	331
23	640	-8	632	310	5	315	317
24	626	-8	618	303	5	308	310
25	615	-8	607	300	5	305	302
26	600	-7	593		5		
27	582	-7	575				
28	573	-7	566	285	5	290	276
29	563	-7	556	280	5	285	271
30	550	-7	543	276	5	281	262
31	540	-7	533	270	5	275	258
32	530	-7	523	270	5	275	248
33	520	-7	513	265	5	270	243
34	510	-7	503	260	5	265	238
35	500	-7	493	255	5	260	233
36	490	-6	484	250	6	256	228
37	480	-6	474	240	6	246	228
38	465	-6	459	235	6	241	218
39	460	-6	454	231	6	237	217
40	450	-6	444	230	6	236	208
41	440	-6	434	228	6	234	200

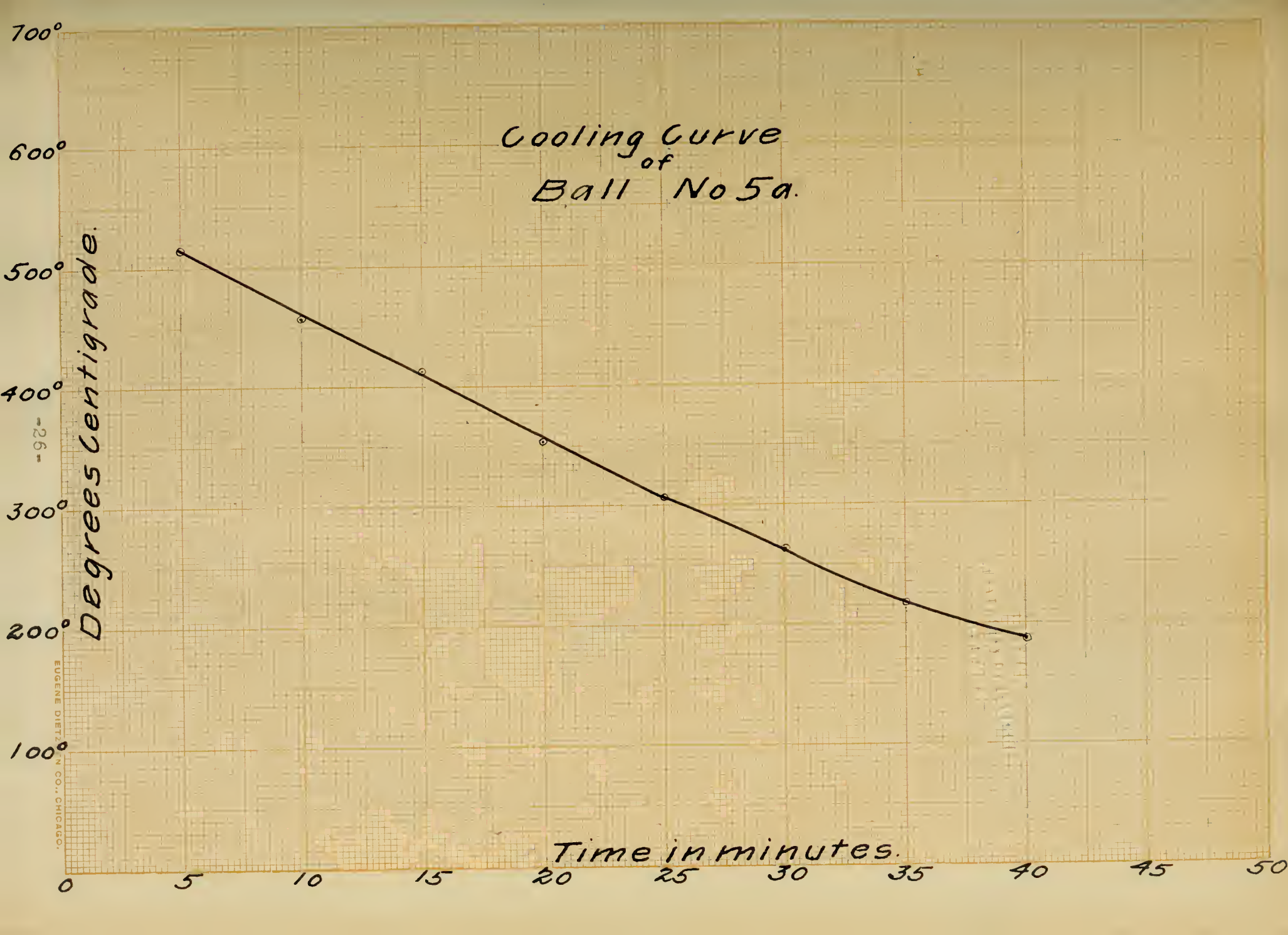


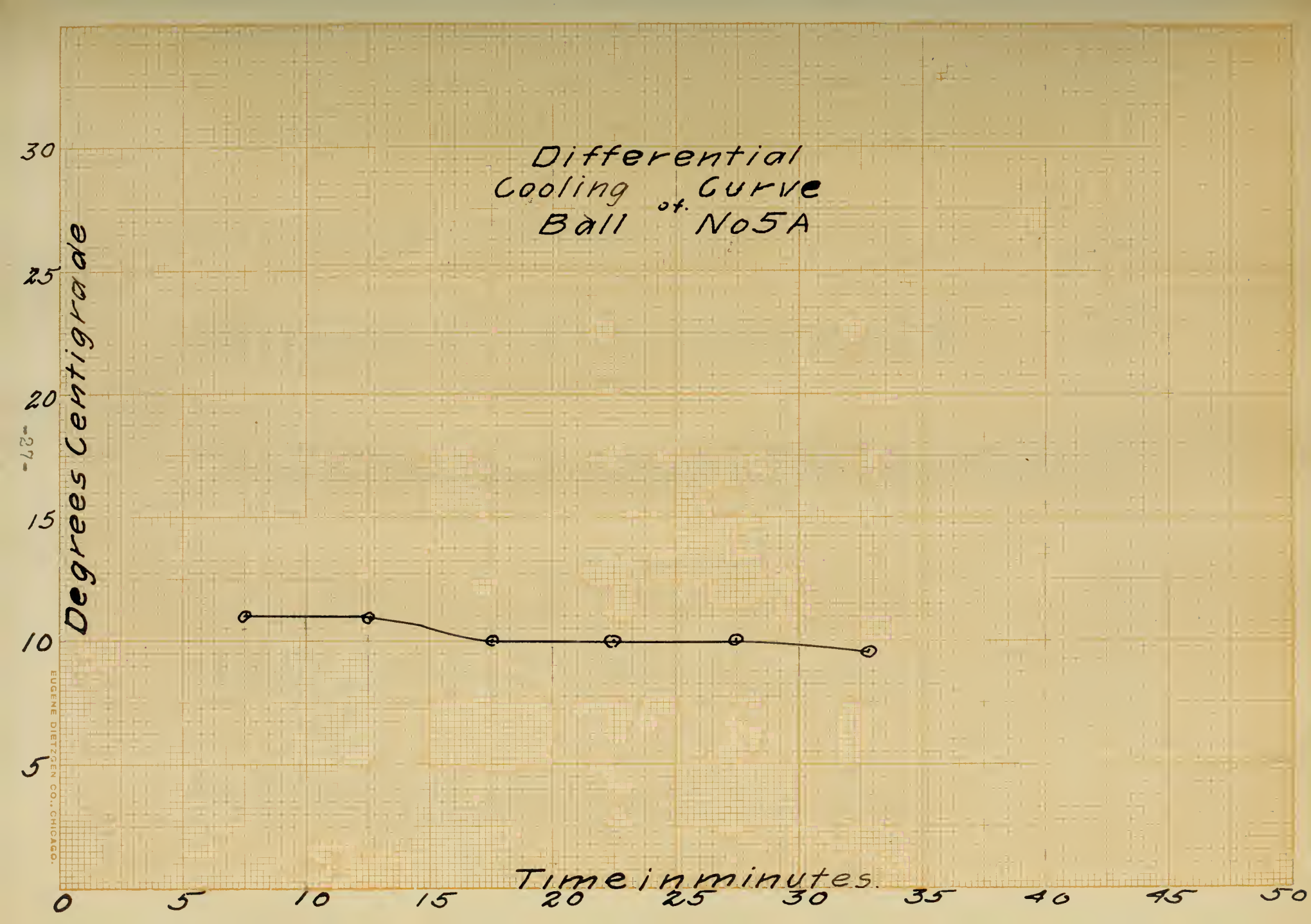


D A T A S H E E T.

Ball No. 5 a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1120			570			
1	1110			560			
2	1100			570			
3	1090			560			
4	1070	-0	1070	540	3	543	527
5	1050	-2	1048	530	3	533	515
6	1030	-4	1026	520	3	523	503
7	1005	-8	997	500	3	503	494
8	980	-9	971	490	4	494	477
9	960	-10	950	480	4	484	466
10	940	-10	930	470	4	474	456
11	920	-10	910	460	4	464	446
12	898	-10	888	450	4	454	434
13	875	-10	865	440	4	444	421
14	850	-9	841	430	4	434	407
15	830	-9	821	405	4	409	412
16	810	-9	801	395	4	399	402
17	788	-9	779	390	4	394	385
18	768	-9	759	380	4	384	375
19	748	-9	739	370	5	375	365
20	725	-8	717	360	5	365	352
21	710	-8	702	350	5	355	347
22	690	-8	682	345	5	350	332
23	675	-8	667	340	5	345	322
24	655	-8	647	330	5	335	312
25	640	-8	632	320	5	325	307
26	625	-8	617	310	5	315	302
27	610	-7	603	305	5	310	293
28	597	-7	590	305	5	310	280
29	580	-7	573	300	5	305	268
30	565	-7	558	292	5	297	261
31	550	-7	543	290	5	295	248
32	540	-7	533	288	5	293	240
33	530	-7	523	282	5	287	236
34	515	-7	508	280	5	285	223
35	505	-7	498	275	5	280	218
36	495	-7	488	270	5	275	213
37	480	-6	474	265	5	270	204
38	470	-6	464	260	5	265	199
39	465	-6	457	260	5	265	192
40	455	-6	447	255	5	260	187
41	448	-6	442	252	5	257	185

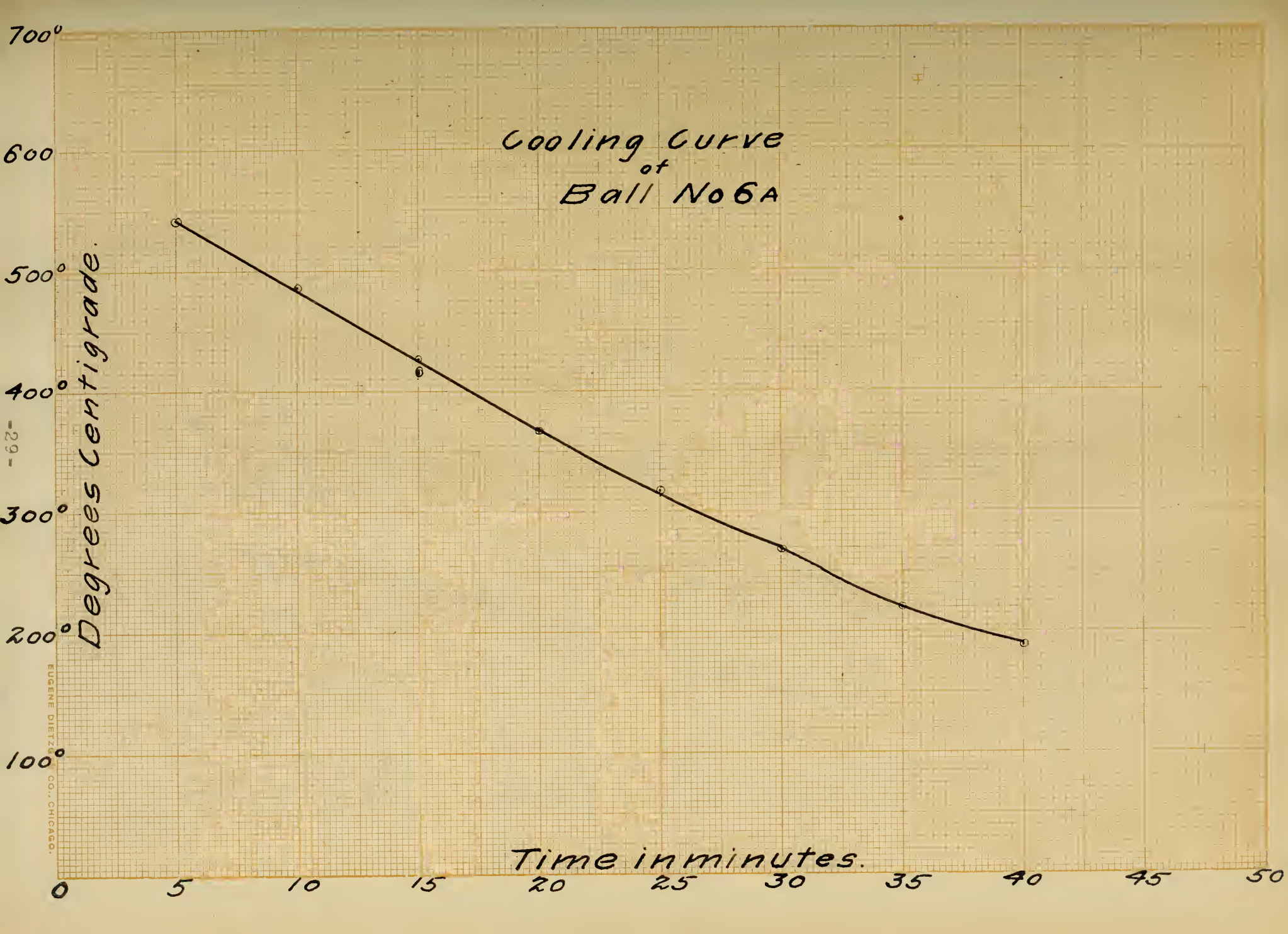


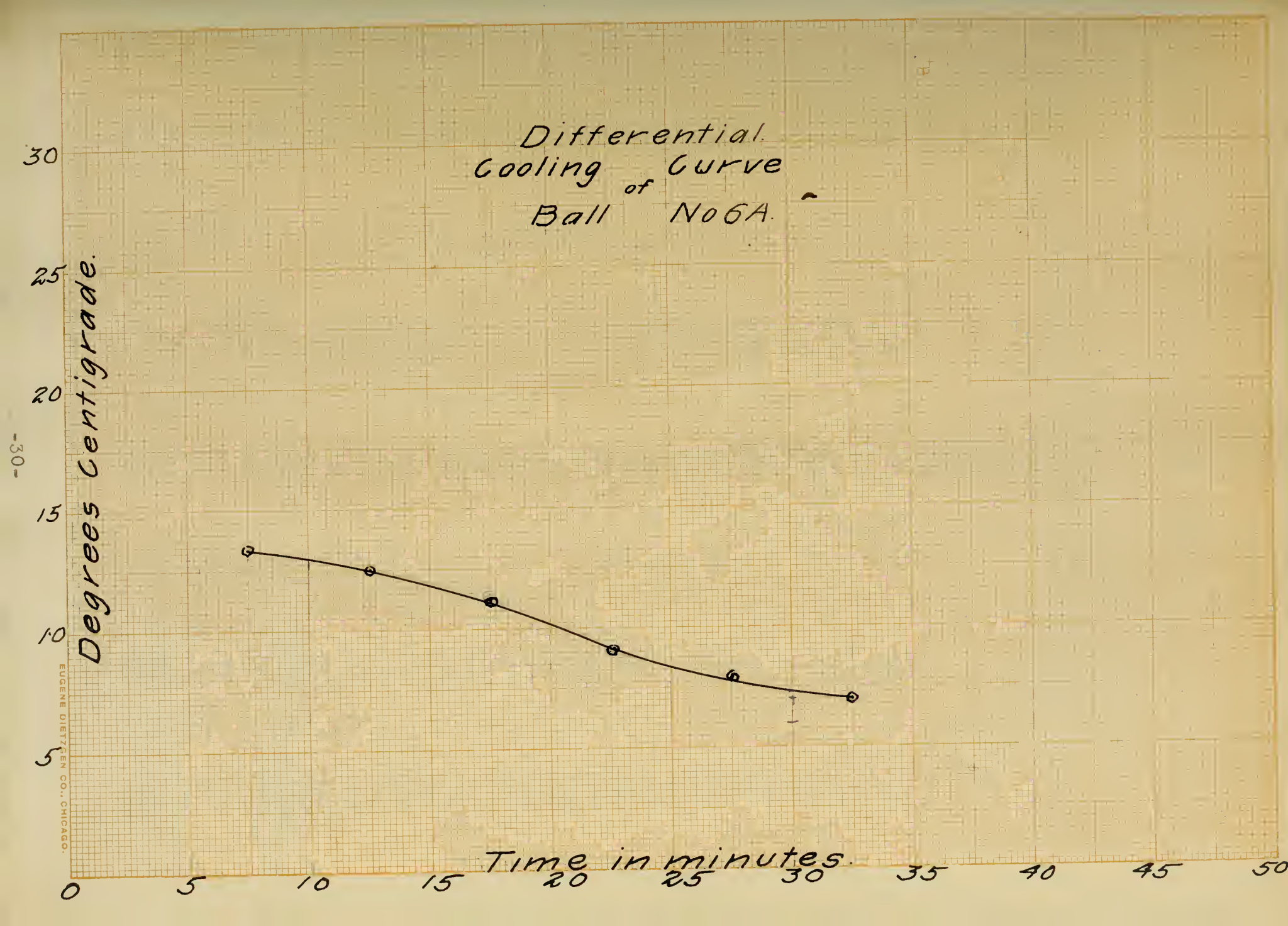

Differential Cooling Curve of Ball No 5A
Degrees Centigrade
30
25
20
15
10
5
Time in minutes.
0
5
10
15
20
25
30
35
40
45
50
EUGENE DIETZGEN CO. CHICAGO.

DATA SHEET.

Ball No. 6 a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1110			580			
1	1110			560			
2	1100			552	3		
3	1090			540	3		
4	1080	-0		530	3		
5	1060	-1	1059	515	3	518	541
6	1040	-3	1037	510	3	513	524
7	1020	-6	1014	595	3	498	516
8	1000	-8	992	580	4	484	508
9	980	-9	971	470	4	474	497
10	960	-10	950	460	4	464	486
11	940	-10	930	450	4	454	476
12	920	-10	910	440	4	444	466
13	895	-10	885	425	4	429	456
14	870	-10	870	415	4	419	441
15	850	-9	841	410	4	414	427
16	830	-9	821	400	4	404	417
17	810	-9	801	390	4	394	407
18	790	-9	781	385	4	389	392
19	770	-9	761	380	4	384	377
20	750	-9	741	370	5	375	366
21	730	-8	722	355	5	360	362
22	710	-8	702	345	5	350	352
23	690	-8	682	335	5	340	342
24	670	-8	662	330	5	335	327
25	650	-8	642	320	5	325	317
26	630	-8	622	318	5	323	299
27	610	-7	603	315	5	320	283
28	600	-7	593	310	5	315	278
29	580	-7	573	300	5	305	268
30	570	-7	363	300	5	305	258
31	560	-7	553	295	5	300	243
32	545	-7	538	290	5	295	243
33	530	-7	523	285	5	290	233
34	520	-7	513	280	5	285	228
35	510	-7	503	278	5	283	220
36	500	-7	493	275	5	280	213
37	490	-6	484	270	5	275	209
38	480	-6	474	265	5	270	204
39	470	-6	464	260	5	265	199
40	460	-6	454	260	5	265	189
41	450	-6	444	255	5	260	184

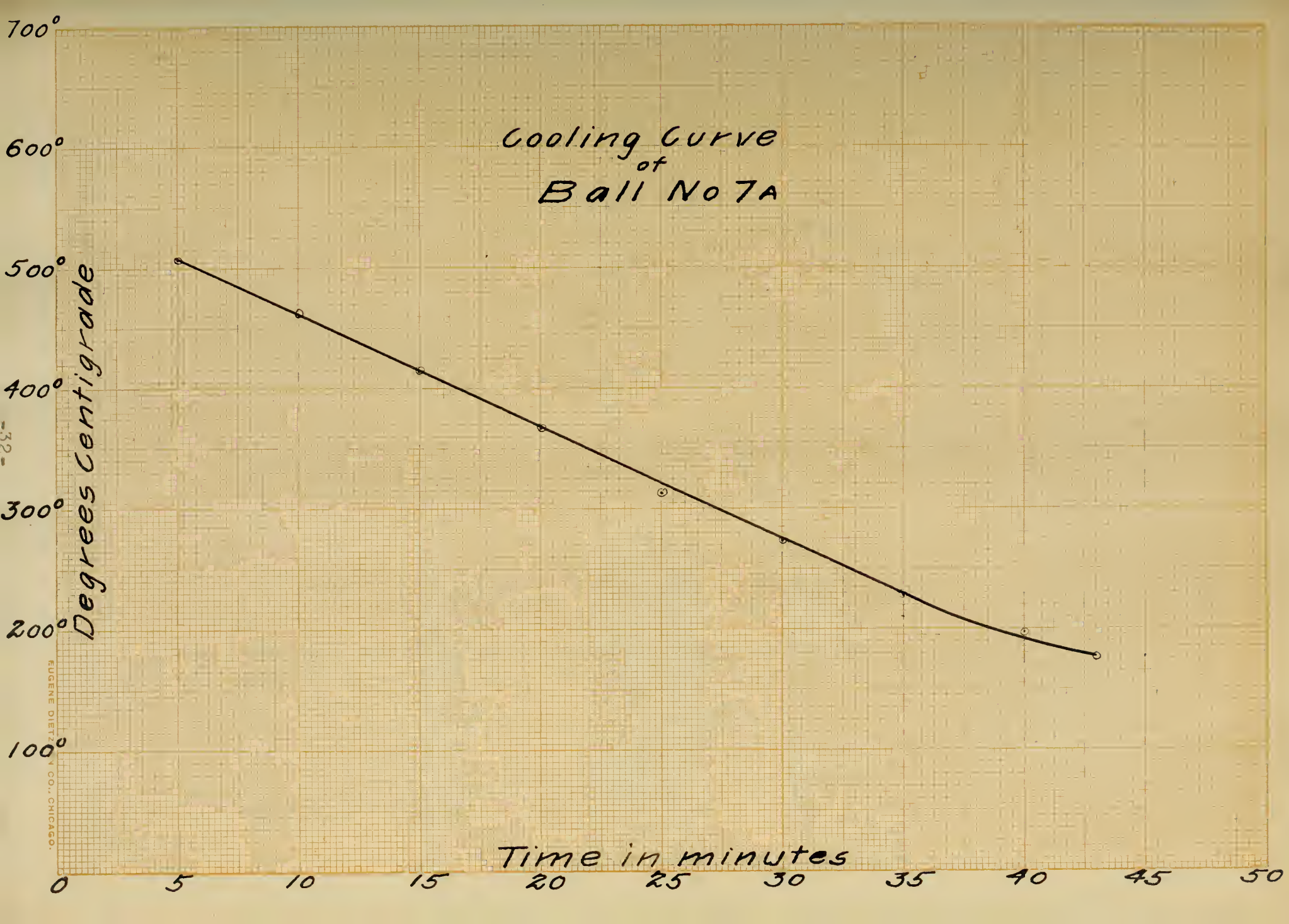


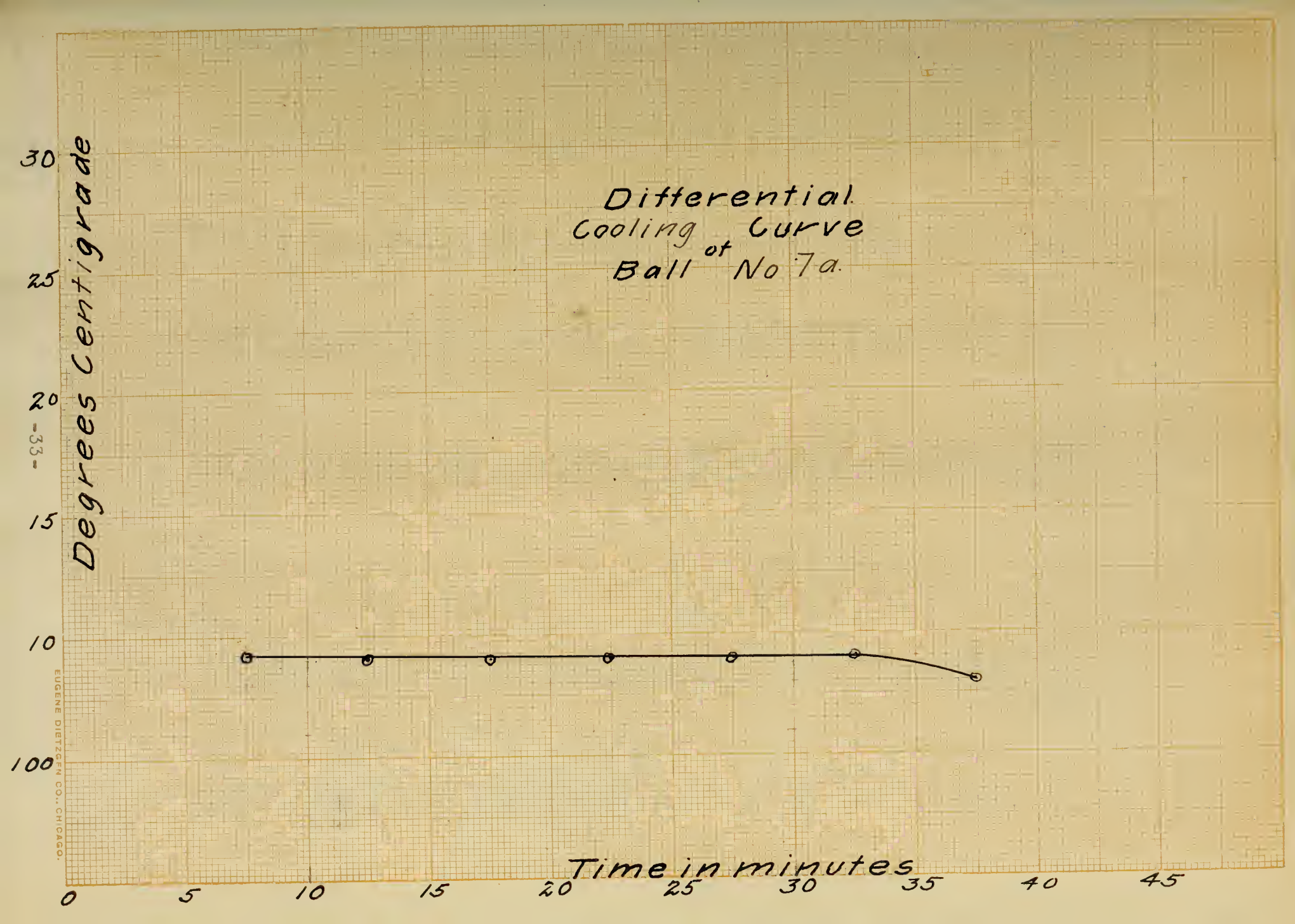


D A T A S H E E T.

Ball No. 7 a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1110			590			
1	1110			600			
2	1100			590			
3	1090			580			
4	1080	-0	1080	565	3	568	512
5	1060	-1	1059	556	3	553	506
6	1045	-3	1042	532	3	535	507
7	1025	-6	1019	520	3	523	496
8	1005	-8	997	510	3	513	484
9	980	-9	971	495	3	498	473
10	965	-10	955	485	3	488	467
11	940	-10	930	470	4	474	456
12	920	-10	910	460	4	464	446
13	900	-10	890	450	4	454	436
14	880	-10	870	440	4	444	426
15	860	-10	850	430	4	434	416
16	835	-9	826	420	4	424	402
17	810	-9	801	410	4	414	387
18	795	-9	786	400	4	404	382
19	770	-9	761	390	4	394	367
20	760	-9	751	380	4	384	367
21	740	-9	731	370	5	375	356
22	720	-8	712	360	5	365	347
23	705	-8	697	350	5	355	342
24	685	-8	677	345	5	350	327
25	665	-8	657	340	5	345	312
26	655	-8	647	330	5	335	312
27	640	-8	632	330	5	335	297
28	625	-8	617	322	5	327	290
29	610	-7	603	320	5	225	278
30	600	-7	593	315	5	320	273
31	585	-7	578	310	5	315	263
32	570	-7	563	305	5	310	253
33	555	-7	548	300	5	305	233
34	540	-7	533	295	5	300	233
35	530	-7	523	290	5	295	228
36	520	-7	513	285	5	290	223
37	510	-7	503	280	5	285	218
38	500	-7	493	280	5	285	208
39	490	-6	484	275	5	280	204
40	480	-6	474	270	5	275	199
41	470	-6	464	265	5	270	194
42	460	-6	454	260	5	265	189
43	450	-6	444	260	5	265	179

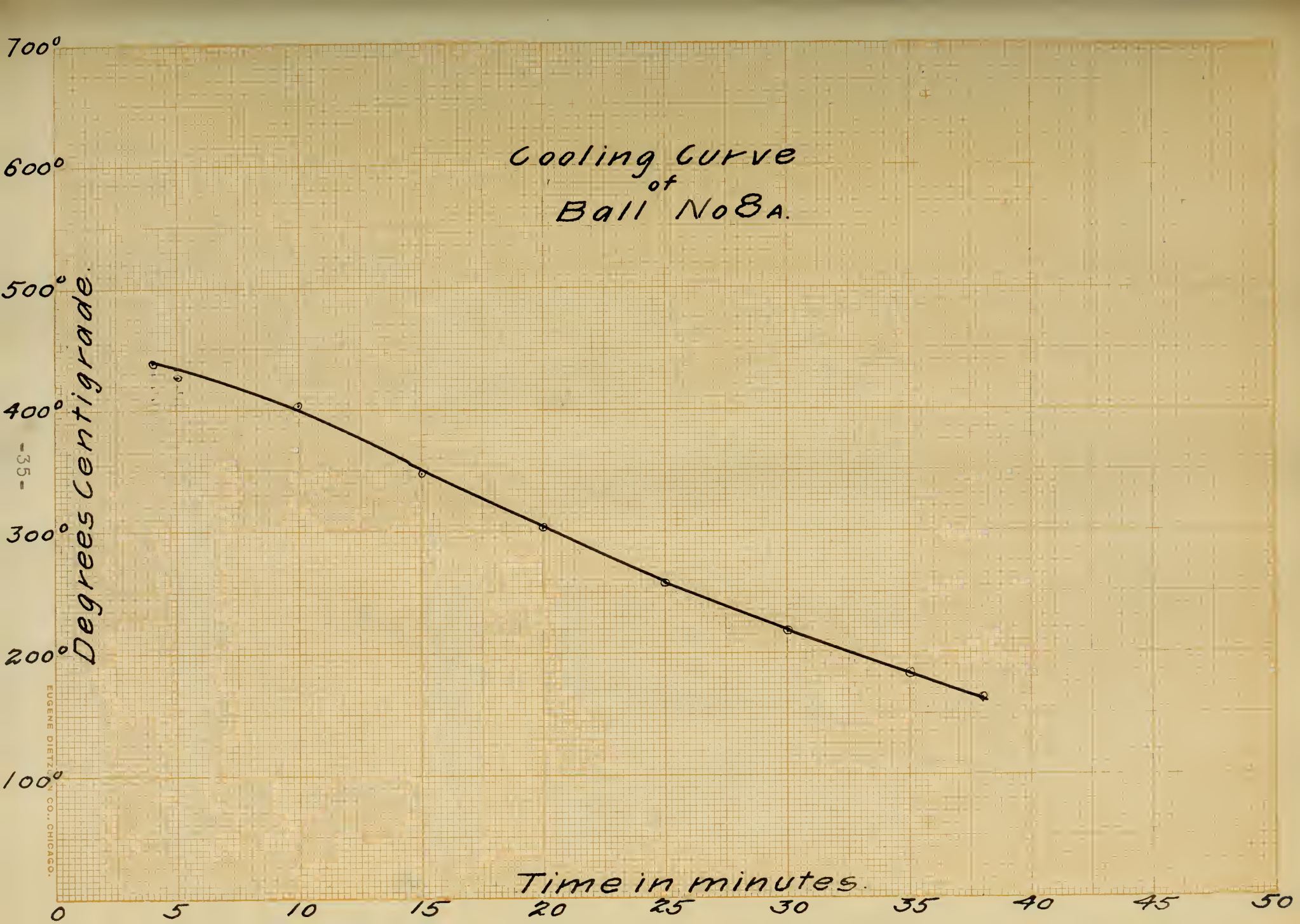


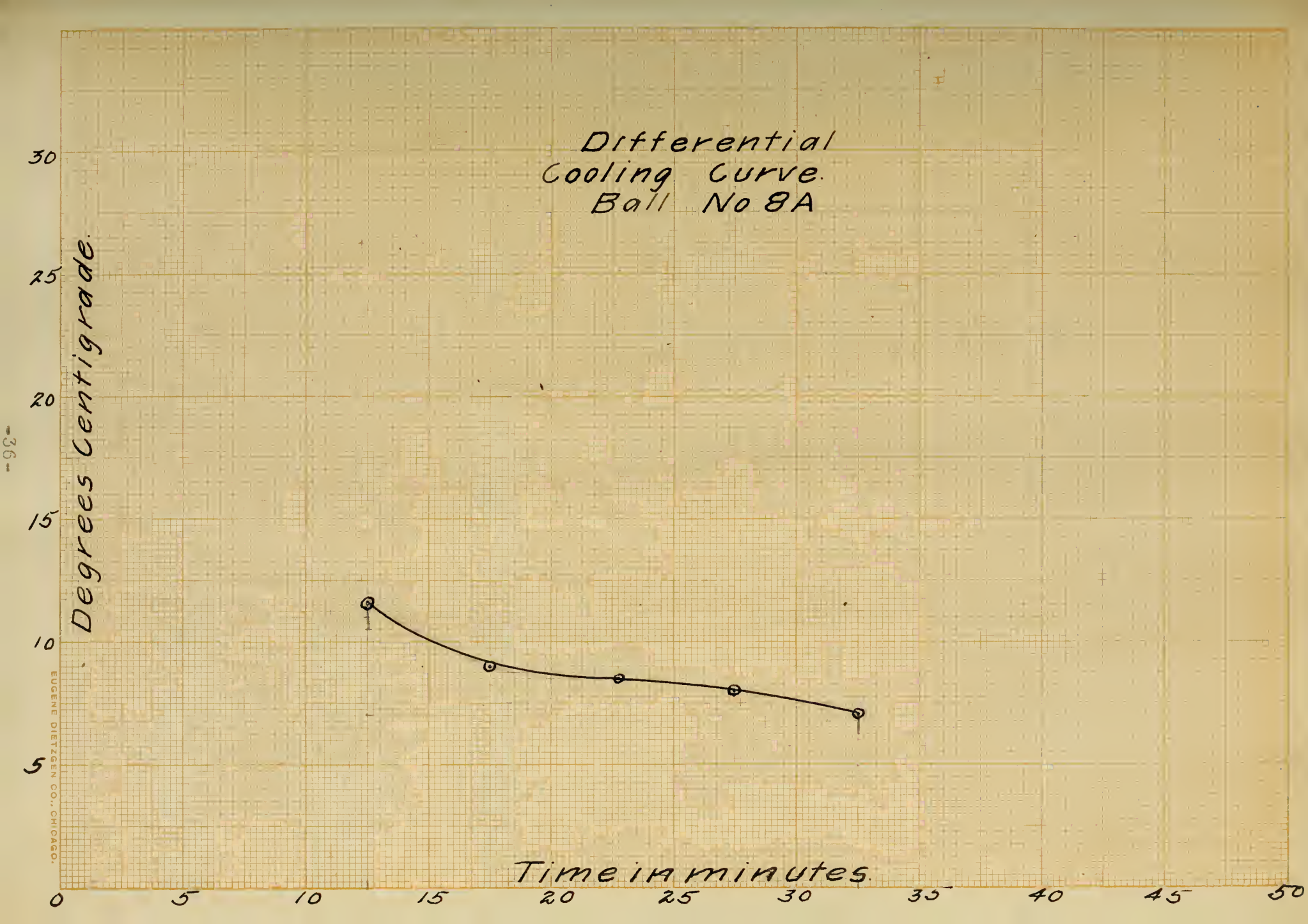


D A T A S H E E T.

Ball No. 8 a.

Time	Observed Inside Couple	Correction	Corrected Inside Couple	Observed Outside Couple	Correction	Corrected Outside Couple	Difference
0	1030	-4	1026	560	2	562	464
1	1020	-6	1014	560	2	562	452
2	1005	-8	993	555	3	558	495
3	990	-9	981	540	3	543	438
4	980	-9	971	530	3	533	438
5	960	-10	950	520	3	523	427
6	940	-10	940	510	3	513	427
7	925	-10	915	475	4	479	456
8	905	-10	895	460	4	464	431
9	875	-10	865	450	4	454	411
10	856	-9	847	440	4	444	403
11	840	-9	831	440	4	444	387
12	825	-9	816	430	4	434	372
13	805	-9	796	423	4	427	369
14	785	-9	776	415	4	419	357
15	765	-9	756	406	4	410	346
16	750	-9	741	398	4	402	339
17	730	-8	722	390	4	394	328
18	710	-8	702	380	4	384	318
19	690	-8	682	370	5	375	307
20	675	-8	667	360	5	365	302
21	660	-8	652	360	5	365	287
22	645	-8	637	355	5	360	277
23	625	-8	617	345	5	350	267
24	610	-7	603	340	5	345	258
25	600	-7	593	332	5	337	256
26	588	-7	581	328	5	333	248
27	575	-7	568	322	5	327	241
28	560	-7	553	315	5	320	233
29	550	-7	543	310	5	315	228
30	538	-7	531	308	5	313	218
31	525	-7	518	300	5	305	213
32	515	-7	508	300	5	305	203
33	505	-7	498	295	5	300	298
34	490	-6	484	290	5	295	289
35	480	-6	474	285	5	290	284
36	470	-6	464	280	5	285	279
37	460	-6	454	275	5	280	274
38	450	-6	444	275	5	280	264

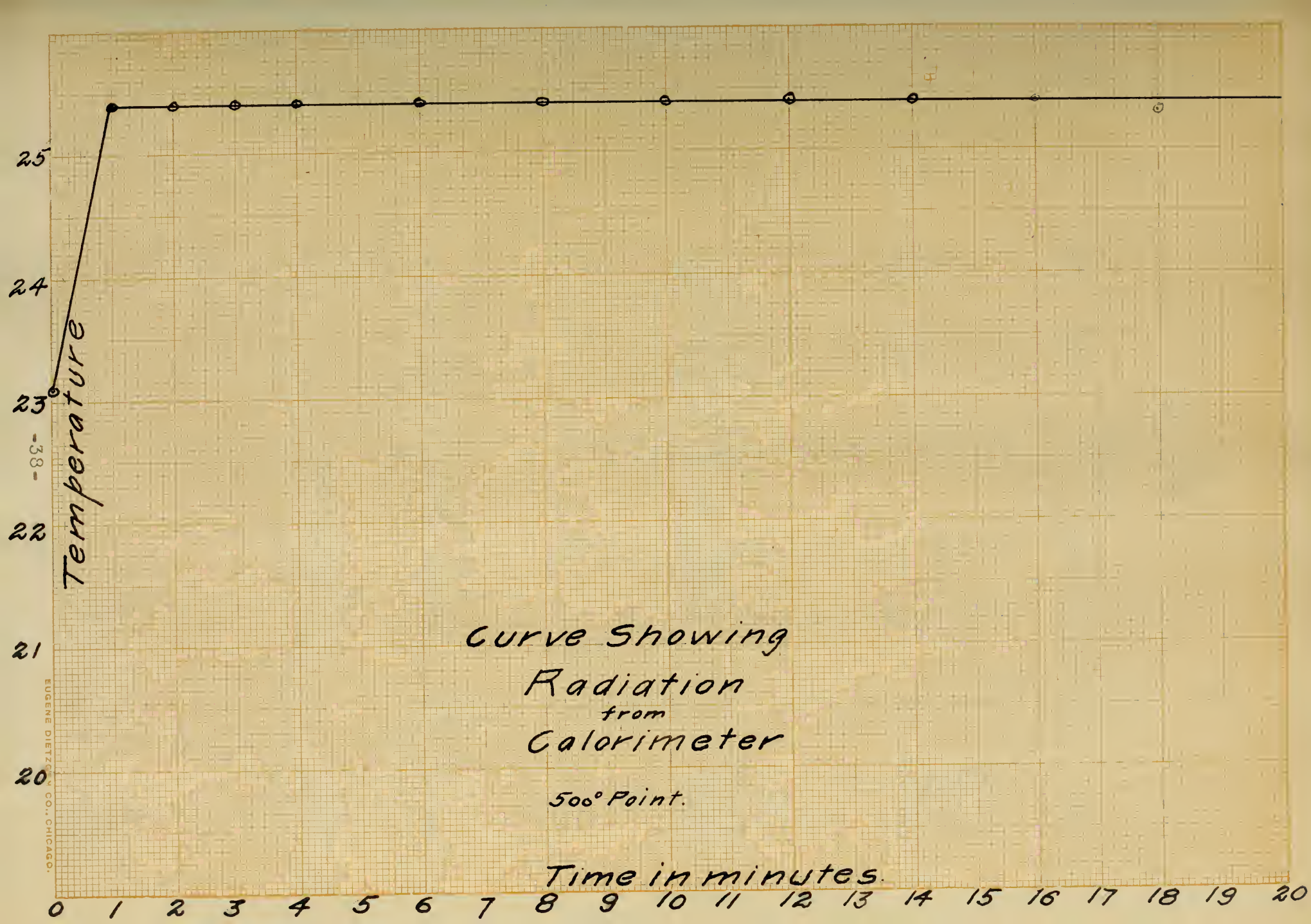



Differential
Cooling Curve.
Ball No 8A
Degrees Centigrade.
30
25
20
15
10
5
Time in minutes.
0
5
10
15
20
25
30
35
40
45
50
EUGENE DIETZGEN CO., CHICAGO.

D A T A S H E E T.

500 Point.

Interval	Initial Temp.	Final Temp.	Mean Temp.
1	23.1	25.4	24.4
2	25.4	25.4	25.4
3	25.4	25.4	25.4
4	25.4	25.4	25.4
5	25.4	25.4	25.4
6	25.4	25.4	25.4
7	25.4	25.4	25.4
8	25.4	25.4	25.4
9	25.4	25.4	25.4
10	25.4	25.4	25.4
11	25.4	25.4	25.4
12	25.4	25.4	25.4
13	25.4	25.4	25.4
14	25.4	25.4	25.4
15	25.4	25.4	25.4
16	25.4	25.4	25.4
17	25.4	25.4	25.4
18	25.4	25.4	25.4
19	25.4	25.39	25.395
20	25.39	25.39	25.39



D A T A S H E E T.

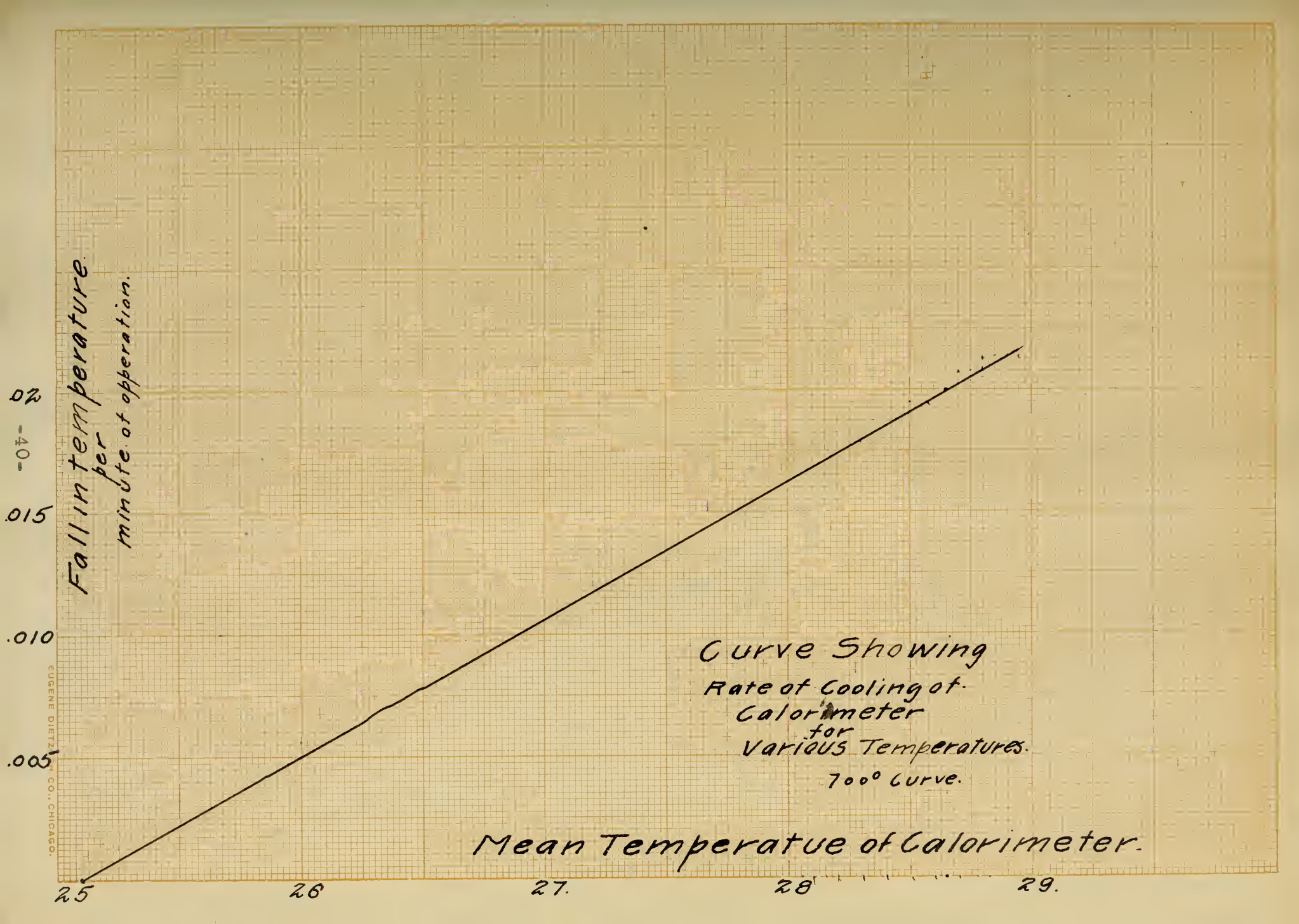
700 Point.

Interval	Initial Temp.	Final Temp.	Mean Temp.	Cooling per Minute Curve.	Correction to be Added to mean temp.	Mean Temp. Correct.
1	25.4	28.0	26.7	.009	.08	26.79
2	28.0	28.6	28.3	.016	.08 + .016 = .096	28.396
3	28.6	28.8	28.7	.020	.016 + .020 = .036	28.736
4	28.8	28.8	28.8	.021	.036 + .021 = .057	28.857
5	28.8	28.8	28.8	.021	.057 + .021 = .079	28.079
6	28.8	28.8	28.8	.021	.079 + .021 = .100	28.900
7	28.8	28.7	28.75	.020	.100 + .020 = .120	28.87
8	28.7	28.7	28.7	.020	.120 + .020 = .140	28.84
9	28.7	28.7	28.7	.020	.140 + .020 = .160	28.86
10	28.7	28.65	28.67	.020	.160 + .020 = .180	28.85
11	28.65	28.65	28.65	.020	.180 + .020 = .200	28.85
12	28.65	28.60	28.62	.020	.200 + .020 = .220	28.84
13	28.60	28.60	28.60	.019	.220 + .019 = .239	28.84
14	28.60	28.60	28.60	.019	.239 + .019 = .258	28.86
15	28.60	28.60	28.60	.019	.258 + .019 = .279	28.88
16	28.60	28.60	28.60	.019	.279 + .019 = .298	28.89
17	28.60	28.60	28.60	.019	.298 + .019 = .317	28.91
18	28.60	28.55	28.57	.019	.317 + .019 = .336	28.91
19	28.55	28.55	28.55	.018	.336 + .018 = .354	28.90
20	28.55	28.55	28.55	.018	.354 + .018 = .372	28.92
21	28.55	28.51	28.52	.018	.372 + .018 = .390	28.91
22	28.51	28.51	28.51	.018	.390 + .018 = .408	28.91

23.8 + 28.3 = 52.1 ÷ 2 = 26.05

28.8 - 28.51 = .29 ÷ 18 = .016 per min.

700 P.


Fall in temperature per minute of operation.
.02
-40-
.015
.010
.005
Curve Showing
Rate of Cooling of
Calorimeter
for
Various Temperatures.
700° Curve.
Mean Temperatue of Calorimeter.
25
26
27.
28
29.
EUGENE DIETZGEN CO., CHICAGO.

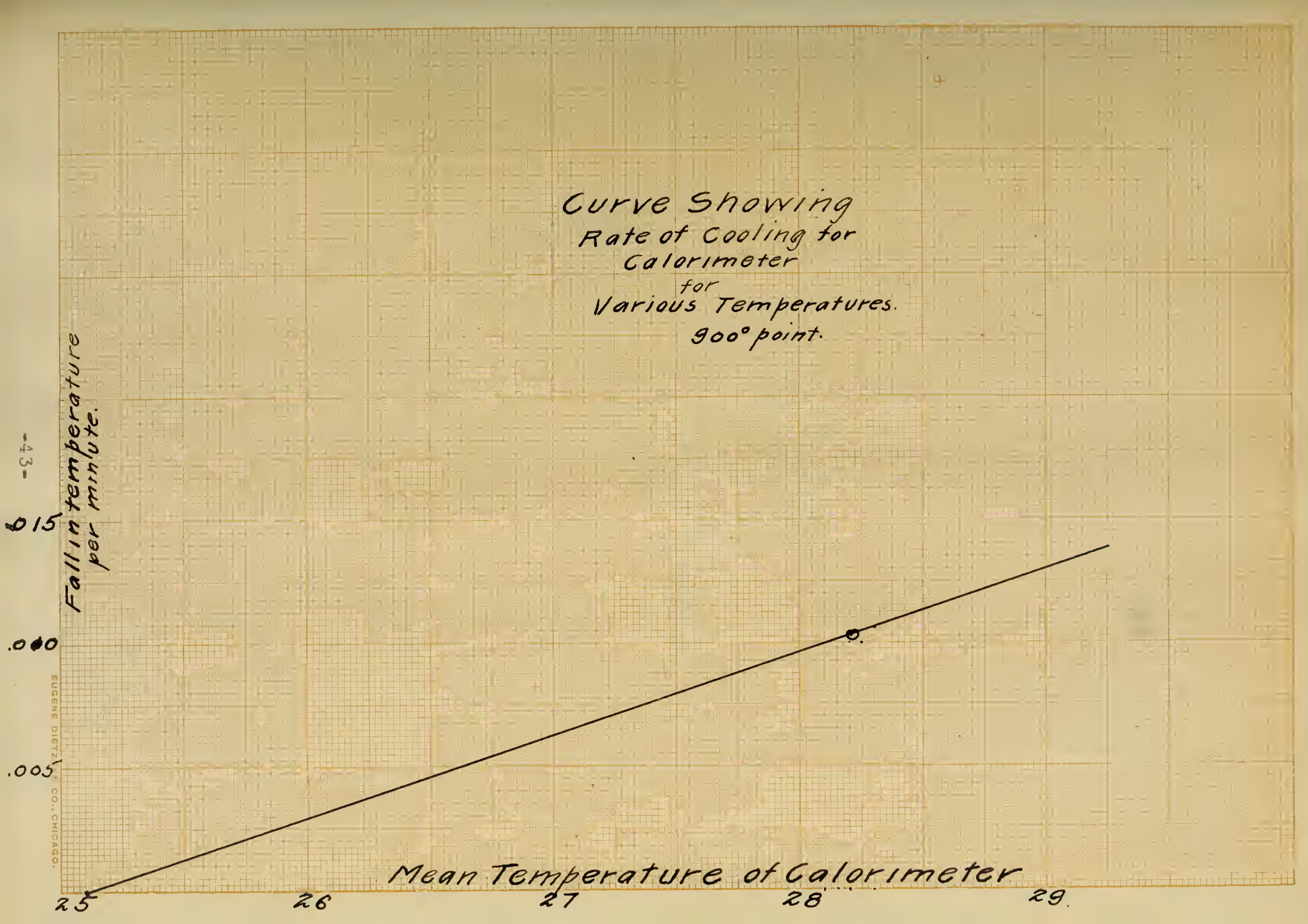

Temperature.
30
29
28
27
26
25
Curve Showing
Loss of Heat from
Calorimeter during
heating
700° pt.
Time in minutes
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
EUGENE DIETZGEN CO., CHICAGO.

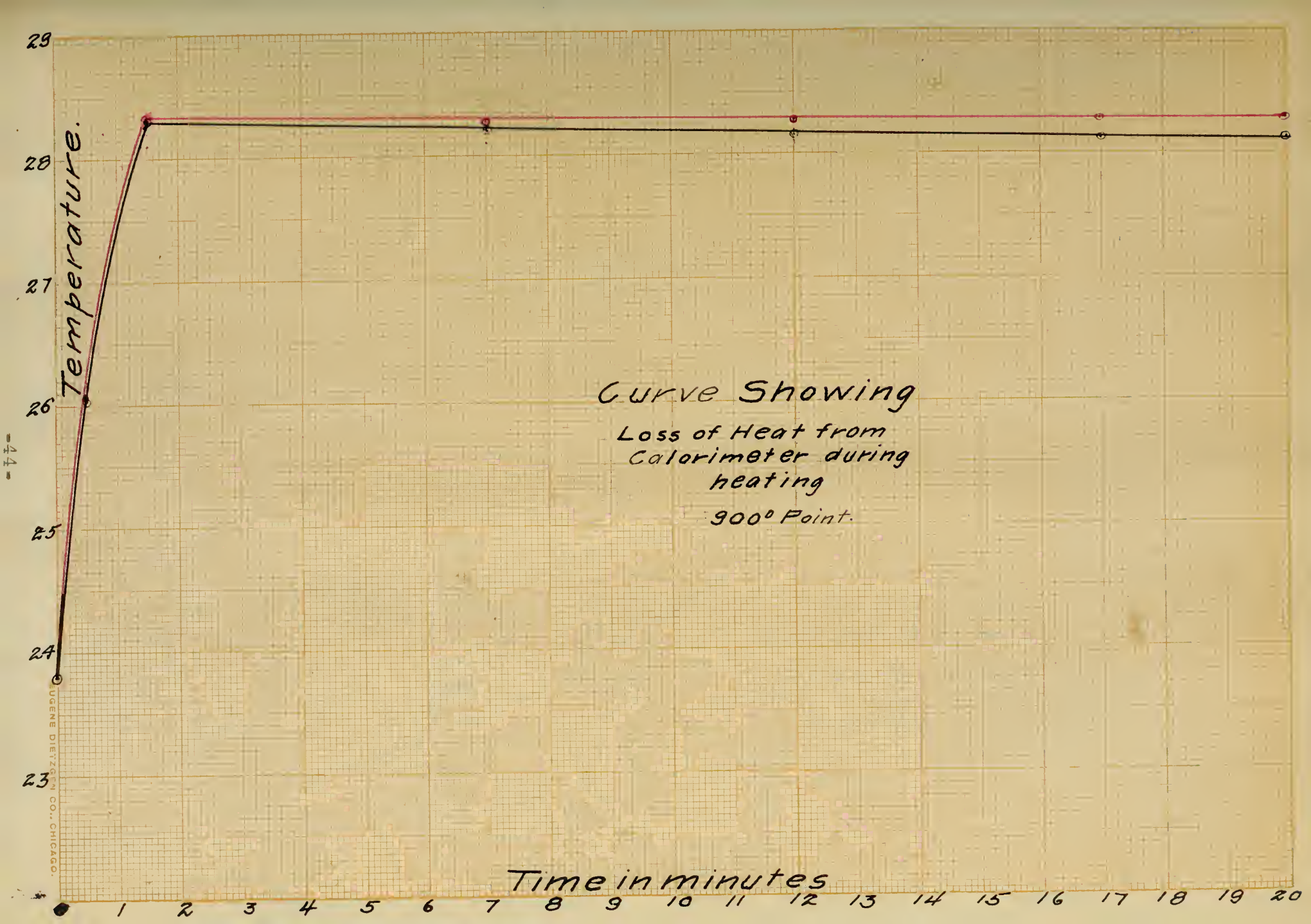
D A T A S H E E T.

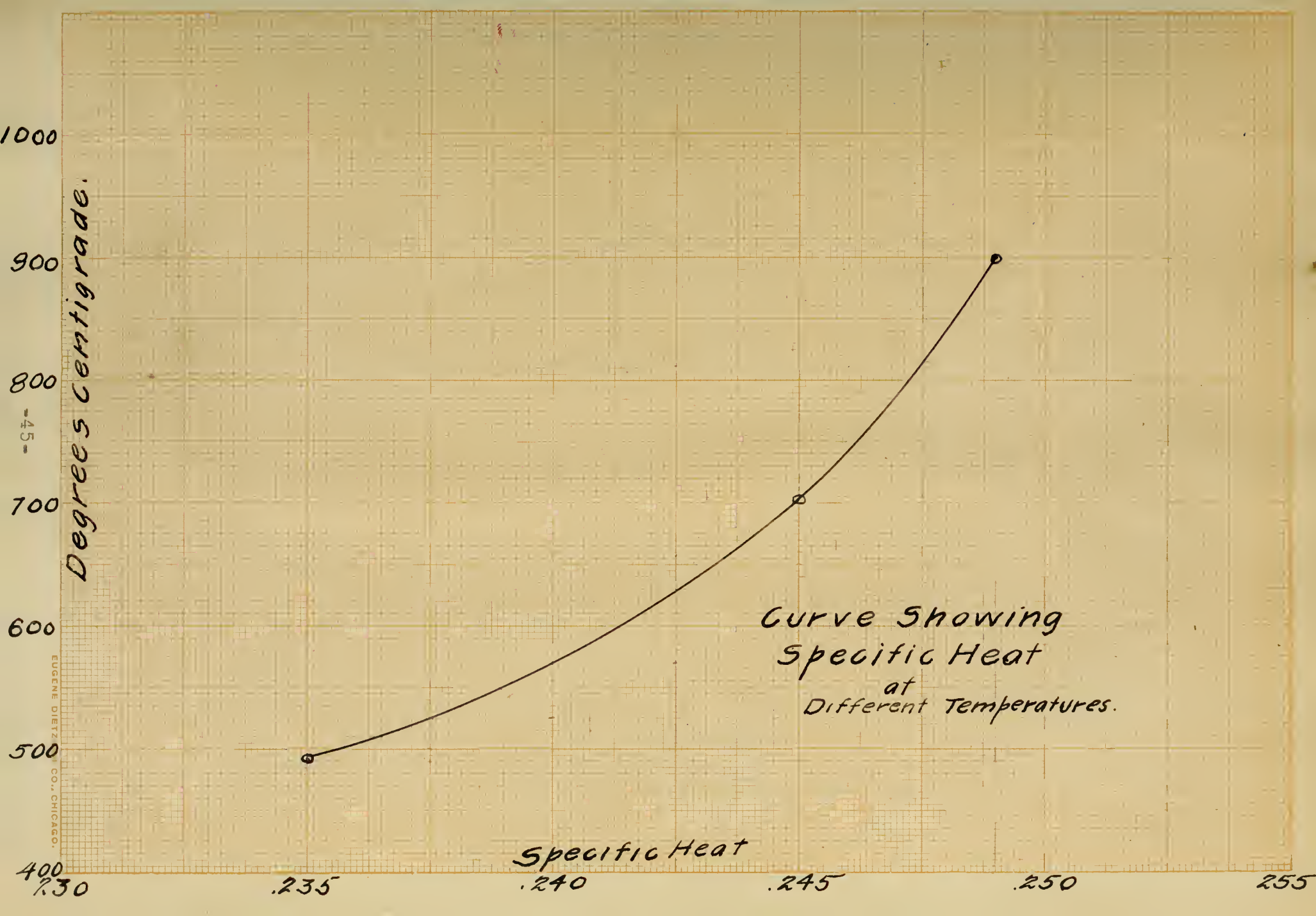
900 Point.

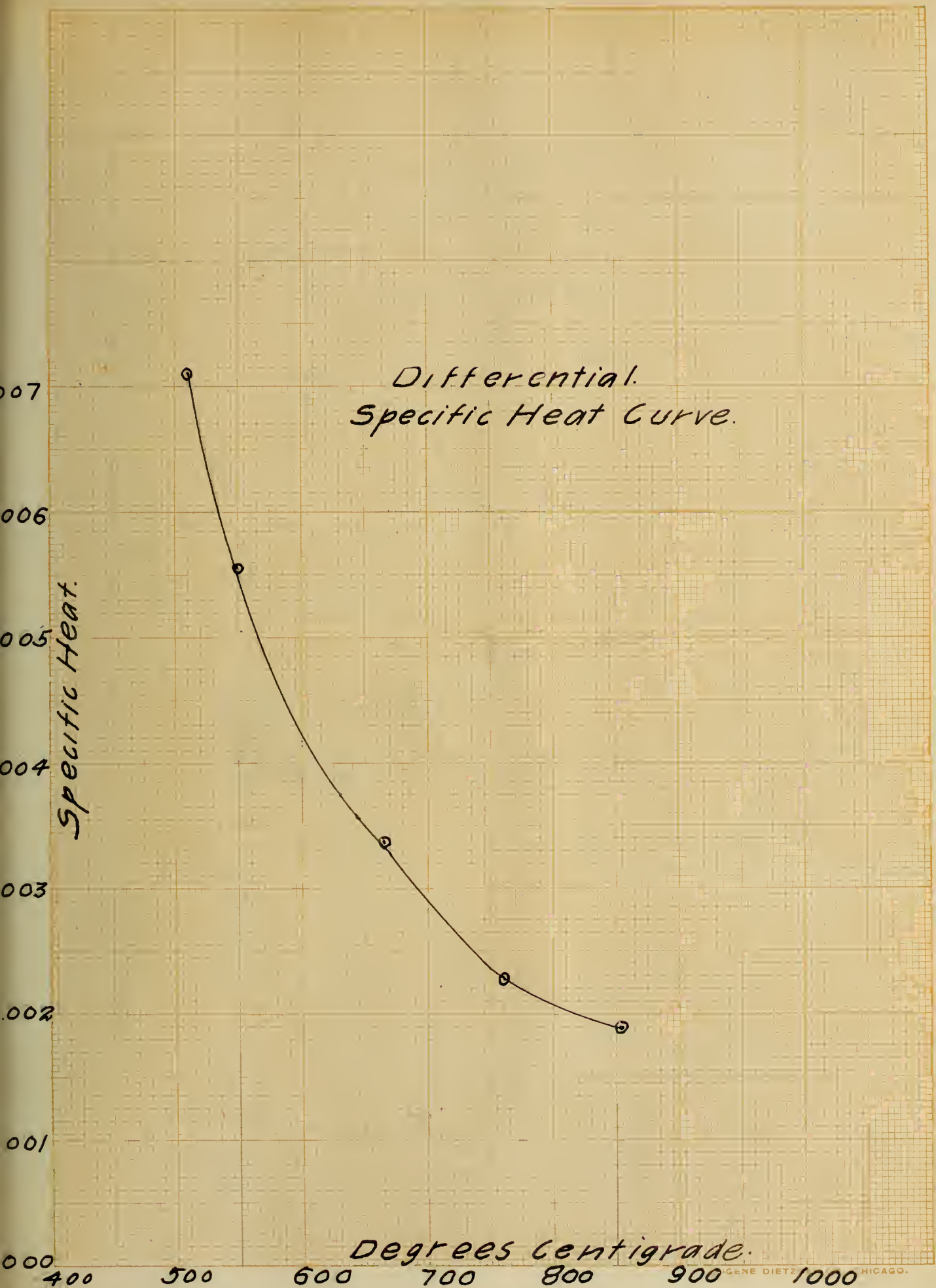
Interval	Initial Temp.	Final Temp.	Mean Temp.	Cooling during minute	Correction to be Added to mean temp.	Mean Temp Correct.
1	23.8	28.3	26.05	.003	.003	26.053
2	28.3	28.3	28.3	.011	.003 + .011 = .014	28.314
3	28.3	28.3	28.3	.011	.014 + .011 = .025	28.325
4	28.3	28.25	28.27	.010	.025 + .010 = .035	28.305
5	28.25	28.25	28.25	.010	.035 + .010 = .045	28.295
6	28.25	28.2	28.22	.010	.045 + .01 = .055	28.275
7	28.2	28.2	28.20	.010	.055 + .01 = .065	28.265
8	28.2	28.2	28.20	.010	.065 + .01 = .075	28.275
9	28.2	28.18	28.19	.010	.075 + .01 = .085	28.275
10	28.18	28.18	28.18	.010	.085 + .01 = .095	28.275
11	28.18	28.16	28.17	.010	.095 + .01 = .105	28.275
12	28.16	28.14	28.15	.010	.105 + .01 = .115	28.265
13	28.14	28.14	28.14	.010	.115 + .01 = .125	28.265
14	28.14	28.14	28.14	.010	.125 + .01 = .135	28.275
15	28.14	28.14	28.14	.010	.135 + .01 = .145	28.285
16	28.14	28.12	28.13	.010	.145 + .01 = .155	28.285
17	28.12	28.12	28.12	.010	.155 + .01 = .165	28.285
18	28.12	28.12	28.12	.010	.165 + .01 = .175	28.295
19	28.12	28.12	28.12	.010	.175 + .01 = .185	28.305
20	28.12	28.12	28.12	.010	.185 + .01 = .195	28.315

Curve Showing
Rate of Cooling for Calorimeter for Various Temperatures.
900° point.




Temperature.
29
28
27
26
25
24
23
Curve Showing
Loss of Heat from
Calorimeter during
heating
900° Point.
Time in minutes
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
EUGENE DIETZGEN CO., CHICAGO.




Differential.
Specific Heat Curve.
Specific Heat.
.007
.006
.005
.004
.003
.002
.001
.000
400
500
600
700
800
900
1000
Degrees Centigrade.
GENE DIETZ CHICAGO.

D A T A

for

Specific Heat.

500 Pt.

Mass of Calorimeter = 83.57 grams = M_3

Mass of Water + Calorimeter = 561.65 = M_4

Mass Water = M_2 = $(M_4 - M_3)$ = 478.07

Mass Sample = 10.077 = M_1

Initial Temperature = 23.1° C = t_1

Final Temperature (Corrected) = 25.4° C = t_2

Water Equivalent of Calorimeter = 7.06 gr. Cal.

Temp. of Piece = t_3 = 500°

Correction for Couple = t_4 = -7

Calculation.

$$S \quad \frac{(M_4 - M_3)(t_2 - t_1) + 7.06}{M_1[(t_3 - t_4) - t_2]}$$

$$S \quad \frac{(561.65 - 83.57)(25.4 - 23.1) + 7.06}{10.077[(500 - 7) - 25.4]}$$

$$S = .235$$

700 Point.

M = 83.57 t_1 = 25.4 C

M = 558.90 t_2 = 28.9 C

M = 475.32 t_3 = 715 C

M = 10.077 t_4 = -8

$$S \quad \frac{(58.9 - 83.58)\ (28.9 - 25.4) + 7.06}{10.077\left[(715-8) - 28.9\right]}$$

S = .245

900 Point.

M = 10.077 t_1 = 23.8

M = 485.32 t_2 = 28.3

M = 83.57 t_3 = 910

M = 568.90 t_4 = -10

$$S \quad \frac{(568.90 - 83.58)\ (283 - 23.8) + 7.06}{10.077\left[(910-10) - 28.3\right]}$$

S = .249

DATA SHEET

No.	Mass	Radius
0	2820 gr.	6.93 cm.
1	2831	6.57
2	2841	7.10
3	2774	6.93
4	2815	7.10
5	2696	6.96
6	2724	6.96
7	2736	7.02
8	2740	7.10

Density = 2.63 2.66

Mean " = 2.645

Calculations.

a Mass Sp.Heat Drop in T per minute

$$\frac{a}{60 \cdot \text{surface (cm)}^2} = \text{Calories.}$$

No. 0

$$10.35 \times 2820 \times .2355 = 6873.53$$

$$\frac{6873.53}{60 \times (6.93)^2 \times 4\pi} = .189 \text{ Cal.}$$

No. 1

$$9.88 \times 2831 \times .2355 = 6587.00$$

$$\frac{6587.00}{60 \times (6.57)^2 \times 4\pi} = .205 \text{ Cal.}$$

No. 2

$$8.18 \times 2841 \times .2355 = 5472.83$$

$$\frac{5472.83}{60 \times (7.1)^2 \times 4\pi} = .1439 \text{ Cal.}$$

No. 3

$$8.58 \times 2774 \times 2355 = 5605.14$$

$$\frac{5605.14}{60 \times (6.93)^2 \times 4\pi} = .154 \text{ Cal.}$$

No. 4

$$10.97 \times 2815 \times .2355 = 7292.34$$

$$\frac{7292.34}{60 \times (7.1)^2 \times 4\pi} = .1918 \text{ Cal.}$$

No. 5

$$10.07 \times 2696 \times .2355 = 6393.54$$

$$\frac{6393.54}{60 \times (6.96)^2 \times 4\pi} = .175 \text{ Cal.}$$

Calculations (Cont.)

No. 6

10 2725 .2355 6418.47

$$\frac{6418.47}{60 \times (6.96)^2 \times 4\pi} = .176 \text{ Cal.}$$

No. 7

9 2736 × .2355 = 5807.88

$$\frac{5807.88}{60 \times (7.02)^2 \times 4\pi} = .149 \text{ Cal.}$$

No. 8

8.5 × 7740 × .2355 = 5484.79

$$\frac{5484.79}{60 \times (7.1)^2 \times 4\pi} .144 \text{ Cal.}$$

Conclusions.

The data as calculated above show the mean value of the heat given off per sq. cm. per sec. to be 0.1697 gr. calories. Then the mean thermal conductivity would be 0.1697. × 6.96 = 1.1811 gr. calories. This refers, of course, only to the conditions of the experiment, that is, between the limits of temperature difference 616 to 200, with a starting temperature of 1070 on the inside of the sphere. No relation was observed with regard to the additions or the sizes of grog nor their sizes. This is probably due to the fact that the initial burning temperature was too high and hence the body had become too dense owing to advanced vitrification.

References

Thermo Conductivity of Badley Conducting Substances, determined by Neuman's Method by H. Hecht. Bibl. Annder Physik. 28-2 pp.99-100, 1904. Ann de Physik 14.5 pp.1008-1030. Aug.23, 1904. Library (530.5 APV 319, Ser.4 v.14.)

Thermo Conductivity of Rocks. B. O. Pierce (Amer. Acad. Proc.) Aug., 1898, pp. 651-660) Lib. 506. AA.

Heat Insulation and Furnace Construction by R. S. Hutton and J.R.Beard

Effect of Temperature on Thermo Conductivities of Electrical Insulators, C. H. Lees.

Royal Soc. Phil. Trans. pp. 433-466, May, 1905.

Same 337-338 Jan. 1905. Library, 506 RO. V 204 A.

Heat Resistance, W. Kent. Amer.Soc. Mech.Eng. Trans. 24, pp.1-8,1902.

Tests of Heat Insulators, H. Benish and A.Andersen. Zeitschr Vereine Deutsch Ing. 50, pp.1655-1663, Oct. 13, 1906.

Thermal Conductivity of Concrete. Eng. News 55, pp. 723, June 28,1906.

Determination of Heat Conductivity, J. Thovert. Science Abstracts, 1906, pp. 34.

Neuman's Method for determining heat conductivity, G. Glage (Ann. der Physik. 8, 5 pp. 904, Dec. 28, 1905.